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COMPILATION OF UNPUBLISHED MATERIALS INFORMATION

REPUBLIC AVIATION CORPORATION

Farmingdale, L.I., N.Y.

RAC 357-4
(ARD 767-255)
31 March 1962

COMPILATION OF UNPUBLISHED MATERIALS INFORMATION

FOURTH QUARTERLY REPORT

Contract AF33(616)-8084

January 1962 to March 1962

REPUBLIC AVIATION CORPORATION

Farmingdale, L.I., N.Y.

NOTICE

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FOREWORD

This progress report was prepared by the Republic Aviation Corporation, Farmingdale, New York, under USAF Contract AF33(616)-8084. The contract was initiated under Project No. 1 (8-7381), Task No. 73812, "Compilation of Unpublished Materials Information on Company Sponsored Programs." This work was administered under the direction of the Applications Laboratory, Materials Central, Directorate of Advanced Systems Technology, Aeronautical Systems Division, with Mr. F. Giese acting as project engineer.

This quarterly progress report (final report of the contract) describes unpublished Republic materials data compiled during the period 16 January 1962 through 31 March 1962.

The test results reported in this compilation were due to the efforts of many Republic Aviation personnel. Since a list of contributing personnel would be too cumbersome, only the departments responsible for the compilation and editing of the data presented herein are noted. These were as follows: Manufacturing Research and Processes Department (Metallic, Nonmetallic, and Welding), Production Engineering Structures and Materials Test, Quality Control Test Laboratory, Applied Research and Development Materials Laboratory (Applications Group), and Technical Publications.

This program was coordinated at Republic Aviation by Ronald W. McCaffrey of the Applied Research and Development Materials Laboratory (Applications Group).

ABSTRACT

Property data, not heretofore published, are presented for twenty-one materials. These data have been obtained from materials programs conducted by the Republic Aviation Corporation during the past five years. The following materials are contained in the data compilation:

Aluminum Base Alloys:	X2020, 5456
Magnesium Base Alloys:	HK-31, AZ63, FS-1
Titanium Base Alloys:	Ti-4Al-4Mn, Ti-5Al-2.5Sn, Ti-6Al-4V
Low Alloy Steels: (90% Fe or greater)	5Cr-Mo-V
High Alloy Steels: (less than 90% Fe)	17-7PH, INVAR, AISI 302
Nickel Base Alloys:	René 41, K-Monel, U-700, Electroformed Nickel
Plastics:	Epoxy Foams, Epoxy Tooling Resins, Conductive and Reflec- tive Resins
Transparent Materials:	Stretched Plexiglas 55 Plexiglas II

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INTRODUCTION

The environmental and design requirements necessitated by current and advanced aerospace vehicles have created a myriad of divergent material requirements. In order to cope with the critical dependence of new vehicles on materials and to form a foundation for future materials programs, Materials Central has initiated a program to assemble and collate previously unpublished materials data generated within the aerospace industry.

The materials data included in this report have been selected from Republic's materials research and development programs. These programs have been conducted within the past five years under company sponsorship or in support of contractual commitments.

DATA PRESENTATION

The materials information being reported under this contract has been evaluated and selected on the basis of a), its usefulness to designers within the aerospace industry and b), its statistical value to Materials Central (by inclusion of individual test points in lieu of just average test results).

The applicable data are presented in the Appendix on standard data sheets adopted for this contract. These data sheets have been classified and documented with the following pertinent details; general class of data (i.e., mechanical properties, electrical properties, thermo-physical properties, etc.), commercial material identification, material status, heat or batch number, form, processing condition, object of test, Republic Aviation data reference, specimen type, and test method.

A. DATA CLASSIFICATION

To assist the user of this report in locating reported data on any particular material, a five point decimal system has been adopted to identify the type of data presented. This system basically denotes the type of data, major material classification, secondary material classification, specific material, and sequence of data transmitted. Subsequent data to be reported under this contract will be similarly annotated. Such a system will enable the user to readily collate the reported data. A detailed description of the data classification system is given below.

The first characteristic (N_1.) is a number utilized to segregate the basic type of materials data into one of the following categories:

1. Mechanical Properties
2. Thermo-Physical Properties
3. Electrical Properties
4. Chemical Properties
5. Miscellaneous Properties

The second characteristic (.N_2.) is a letter denoting the two major material classifications, namely, "Metallic Materials" and "Special Purpose Materials." For joint design data, the major material classifications have been further annotated as shown below:

1. <u>Metallic Materials</u>

   AF. Metallic Materials - Mechanical Joints
   AG. Metallic Materials - Welded or Brazed Joints
   AH. Metallic Materials - Adhesive Bonded Joints

2. <u>Special Purpose Materials</u>

   BF. Special Purpose Materials - Mechanical Joints
   BG. Special Purpose Materials - Welded or Brazed Joints
   BH. Special Purpose Materials - Adhesive Bonded Joints

The third characteristic (.N_3.) is a number designating the secondary material classification within each of the major material classifications. The major material classifications have thus been sub-divided as follows:

<u>For Metallic Materials (Code A, AF, AG, or AH)</u>

1. Aluminum Base Alloys
2. Magnesium Base Alloys
3. Titanium Base Alloys
4. Beryllium Base Alloys
5. Low Alloy Steels (90% Fe, or greater)
6. High Alloy Steels (less than 90% Fe)
7. Nickel Base Alloys
8. Cobalt Base Alloys
9. Molybdenum Base Alloys
10. Columbium Base Alloys
11. Tantalum Base Alloys
12. Tungsten Base Alloys
13. Miscellaneous Metallics

<u>For Special Purpose Materials (Code B, BF, BG, or BH)</u>

1. Elastomers
2. Fluids (Functional-energy transmitting)
3. Lubricants
4. Adhesives
5. Fuels and Propellants
6. Insulation (acoustic, electric, thermal)
7. Plastics, laminated.

8. Plastics, miscellaneous
9. Sandwich construction
10. Seals and Sealants
11. Textiles
12. Transparent Materials
13. Ceramics
14. Coatings
15. Composites
16. Bearings
17. Miscellaneous Special Purpose Materials

The fourth characteristic ($.N_4.$) is a number describing the specific material (e.g., M-252, 2024, etc.) being reported. This number, when combined with the applicable subdivisions of the major material classification ($.N_2.$) and secondary material classification ($.N_3.$), will identify data on the same material throughout the contract. The numerical identification of each material is based on the sequence of materials information being reported within each of the secondary material classifications (i.e., if 2014 is the first aluminum alloy reported, X2020 the second and 7075 the third, they would be numbered .1, .2, and .3, respectively).

The fifth and last characteristic ($.N_5$) is a number employed to denote the sequence of data collated for each of the specific materials.

The use of the code is typified by the following examples.

Example 1: The code 1.A.3.2.3 would indicate:

1.	Mechanical Property Data
A.	Metallic Material
3.	Titanium Base Alloy
2.	Ti-5Al-2, 5Sn (2 nd Titanium Base Alloy Reported)
3	3 rd Data Collation for Ti-5Al-2.5Sn

Example 2: The code 1.AG.6.3.1 would indicate:

1.	Mechanical Property Data
AG.	Metallic Materials - Welded or Brazed Joint
6.	High Alloy Steel (less than 90% Fe)
3.	AM-350 (3 rd High Alloy Steel reported)
1	1 st Data Collation for AM-350

B. MATERIALS STATUS - DEFINITION

In order to permit Republic's materials data to be placed in the proper perspective when compared with similar data from other industry sources, each set of data has been annotated with the commercial status of the material tested, i.e., either production, semi-production, or experimental. These terms are defined as follows:

Production:	Material which is readily available in commercial sizes and is usually covered by an approved AMS, MIL, or Federal material specification.
Semi-production:	Material which is commercially available in limited sizes and quantities and may not be covered by an AMS, MIL, or Federal material specification.
Experimental:	Material which is still undergoing laboratory development, is available in only small lots and sizes, and is usually not covered by any material specification.

C. SPECIMEN TYPES AND TEST METHODS

Generally, the specimen types and test methods employed at Republic Aviation for material evaluation are in conformance with an applicable Federal, military, or industry recognized testing specification. Whenever possible, and for the sake of brevity, an applicable testing specification has been noted on the standard data sheets. For those tests which are not covered by an applicable specification, the pertinent test details are recorded. In some cases, the reported data were generated prior to the formalization of an approved testing standard. In those cases where Republic's testing procedure was identical to a procedure subsequently adopted as a standard, the details of test are noted as "the same as Specification. . . ."

The pertinent details of testing, peculiar to the testing specifications noted on the standard data sheets, have been described in the First Quarterly Report issued under this contract as Report No. RAC 767-251(357) dated 14 July, 1961.

REFERENCES

1. First Quarterly Report RAC 767-251(357), dated 14 July 1961.
2. Second Quarterly Report RAC 357-1(ARD 767-252), dated 12 October 1961.
3. Third Quarterly Report RAC 357-2(ARD 767-254), dated 12 January 1962.

MASTER DATA INDEX

To assist the user of this report in ascertaining as to what data is presented under each data classification, a Master Data Index section is included in the following section. Data presented in previous quarterly reports are included in the index.

METALLIC MATERIALS

MASTER DATA INDEX

Material	Code	Material Form									Data Type							Environment				Processing Variable									QUARTERLY REPORT
		Sheet and Plate	Bar	Extrusion	Forging	Casting	Honeycomb	Joint	Composite	Miscellaneous	Tension	Compression	Shear	Bearing	Fatigue	Creep	Miscellaneous	None	Unstressed Heating	Stressed Heating	Miscellaneous	None	Heat Treat	Mech. Working	Welding	Brazing	Bonding	Cleaning Method	Surface Finish	Miscellaneous	
Aluminum 2014	1.A.1.1.1				*						*								*			*									1
X2020	1.A.1.2.1	*									*							*						*							1
	1.A.1.2.2	*									*							*					*								1
	1.A.1.2.3	*									*							*					*								1
	1.A.1.2.4	*									*										15 V *								*		4
	1.AG.1.2.5	*									*								*						*						4
	1.A.1.2.6	*									*	*			*			*				*									4
7075	1.A.1.3.1	*									*								*			*									1
	1.A.1.3.2	*													*			*						*							1
	1.A.1.3.3	*									*							*						*							2
	1.A.1.3.4	*									*							*						*							2
	1.A.1.3.5	*									*				*			*						*							2
	1.A.1.3.6	*									*							*	*			*									3
	1.A.1.3.7	*									*							*					*								3

15 V Salt Spray

METALLIC MATERIALS

MASTER DATA INDEX																															
Material	Code	Material Form									Data Type							Environment				Processing Variable									QUARTERLY REPORT
		Sheet and Plate	Bar	Extrusion	Forging	Casting	Honeycomb	Joint	Composite	Miscellaneous	Tension	Compression	Shear	Bearing	Fatigue	Creep	Miscellaneous	None	Unstressed Heating	Stressed Heating	Miscellaneous	None	Heat Treat	Mech. Working	Welding	Brazing	Bonding	Cleaning Method	Surface Finish	Miscellaneous	
Aluminum 7079	1.A.1.4.1				*						*								*			*									1
2024	1.A.1.5.1	*									*								*			*									2
	1.A.1.5.2	*									*				*			*	*				*	*							2
	1.A.1.5.3	*									*							*	*			*									3
	1.A.1.5.4	*									*							*	*												3
	1.AG.1.5.5	*						*					*			1 V	*	*					*		*						3
X2219	1.A.1.6.1		*								*	*	*		*			*	*			*									2
5052	1.A.1.7.1									* 14 V							* 13 V	*						*							3
5456	1.AG.1.8.1	*									*						* 2 V	*							*						4

1 V Tension Pull Out

14 V Tubing

13 V Bend Data

METALLIC MATERIALS

MASTER DATA INDEX																														
Material	Code	Material Form									Data Type							Environment				Processing Variable									QUARTERLY REPORT
		Sheet and Plate	Bar	Extrusion	Forging	Casting	Honeycomb	Joint	Composite	Miscellaneous	Tension	Compression	Shear	Bearing	Fatigue	Creep	Miscellaneous	None	Unstressed Heating	Stressed Heating	Miscellaneous	None	Heat Treat	Mech. Working	Welding	Brazing	Bonding	Cleaning Method	Surface Finish	Miscellaneous	
Magnesium HK31	1.AG.2.1.1	*						*					*			1V	*	*							*						1
	1.A.2.1.2	*									*							*	*				*								1
	1.A.2.1.3	*									*								*			*									4
HM21XA	1.AG.2.2.1	*						*					*				1V *	*							*						3
AZ63	1.A.2.3.1					*					*							*					*								4
FS-1	1.A.2.4.1	*									*								*			*									4

METALLIC MATERIALS

MASTER DATA INDEX																															
Material	Code	Material Form									Data Type							Environment				Processing Variable									
		Sheet and Plate	Bar	Extrusion	Forging	Casting	Honeycomb	Joint	Composite	Miscellaneous	Tension	Compression	Shear	Bearing	Fatigue	Creep	Miscellaneous	None	Unstressed Heating	Stressed Heating	Miscellaneous	None	Heat Treat	Mech. Working	Welding	Brazing	Bonding	Cleaning Method	Surface Finish	Miscellaneous	QUARTERLY REPORT
Titanium																															
Ti-4Al-4Mn	1.A.3.1.1	*								16	*	*						*	*			*									1
	1.A.3.1.2			*						V	*							*	*			*									1
	1.A.3.1.3		*							*	*				*			*	*			*									4
Ti-5Al-2.5Sn	1.A.3.2.1	*									*						2V *	*	*			*									1
	1.A.3.2.2	*									*							*	*			*									1
	1.A.3.2.3	*	*								*	*	*	*			2V *	*	*			*									1
	1.A.3.2.4	*									*				*			*	*				*								1
	1.AG.3.2.5	*											*		*				*						*						4
Ti-6Al-4V	1.A.3.3.1	*									*				*			*	*			*									2
	1.A.3.3.2			*							*				*		2	*													2
	1.A.3.3.3	*									*						V			*		*							*		3
	1.AG.3.3.4	*									*						*						*		*						4

2/V Bend Test

16
V Billet

METALLIC MATERIALS

MASTER DATA INDEX

Material	Code	Material Form									Data Type							Environment				Processing Variable									QUARTERLY REPORT
		Sheet and Plate	Bar	Extrusion	Forging	Casting	Honeycomb	Joint	Composite	Miscellaneous	Tension	Compression	Shear	Bearing	Fatigue	Creep	Miscellaneous	None	Unstressed Heating	Stressed Heating	Miscellaneous	None	Heat Treat	Mech. Working	Welding	Brazing	Bonding	Cleaning Method	Surface Finish	Miscellaneous	
Ti-8Mn	1.A.3.4.1	*													*			*											*		2
	1.A.3.4.2	*									*								*			*									2
	1.A.3.4.3	*									*							*					*								3
	1.A.3.4.4	*									*						2▽ *	*	*			*									3
	1.A.3.4.5	*									*				*			*												3▽ *	3
Ti-13V-11Cr-3Al (B120 VCA)	1.A.3.5.1	*									*	*						*	*				*								3
Ti-16V-2.5 Al	1.A.3.6.1	*									*				*			*	*			*									3
Ti-4Al-3Mo-1V	1.A.3.7.1	*									*				*			*	*			*									3

3▽ Machining

METALLIC MATERIALS

MASTER DATA INDEX

Material	Code	Material Form									Data Type							Environment				Processing Variable									QUARTERLY REPORT
		Sheet and Plate	Bar	Extrusion	Forging	Casting	Honeycomb	Joint	Composite	Miscellaneous	Tension	Compression	Shear	Bearing	Fatigue	Creep	Miscellaneous	None	Unstressed Heating	Stressed Heating	Miscellaneous	None	Heat Treat	Mech. Working	Welding	Brazing	Bonding	Cleaning Method	Surface Finish	Miscellaneous	
Low Alloy Steels																															
SAE4340	1.AG.5.1.1	*									*							*	*						*						1
A1S1	1.A.5.2.1					*					*				*			*			4 V	*							5 V	6 V	2
4330 Mod.	1.A.5.2.2		*								*				*																2
5CR-Mo-V	1.A.5.3.1		*								*				*			*				*									3
	1.AG.5.3.2	*									*				*			*	*						*						3
	1.A.5.3.3		*								*								*			*									4
	1.A.5.3.4	*									*				*				*			*									4
AMS 6407	1.AG.5.4.1	*									*							*							*						3
SAE4130	1.AG.5.5.1			*							*							*							*						3

4
V H_2 Embrittlement

5
V Cd Plating

6
V Electrolytic immersion in H_2SO_4

METALLIC MATERIALS

MASTER DATA INDEX																															
Material	Code	Material Form									Data Type							Environment				Processing Variable									QUARTERLY REPORT
		Sheet and Plate	Bar	Extrusion	Forging	Casting	Honeycomb	Joint	Composite	Miscellaneous	Tension	Compression	Shear	Bearing	Fatigue	Creep	Miscellaneous	None	Unstressed Heating	Stressed Heating	Miscellaneous	None	Heat Treat	Mech. Working	Welding	Brazing	Bonding	Cleaning Method	Surface Finish	Miscellaneous	
High Alloy Steels																															
W545	1.A.6.1.1		*								*							*	*	*		*									1
AISI 431	1.A.6.2.1		*								*		*					*	*			*									1
AM 350	1.AG.6.31	*						*					*				1V *								*						1
PH15-7Mo	1.A.6.4.1	*									*							*					*								1
	1.AG.6.4.2	*						*					*					*					*		*						2
	1.AG.6.4.3	*						*					*				*	*					*		*						3
AM355	1.A.6.5.1					*					*							*	*				*								2

METALLIC MATERIALS

MASTER DATA INDEX																															
Material	Code	Material Form									Data Type							Environment				Processing Variable									QUARTERLY REPORT
		Sheet and Plate	Bar	Extrusion	Forging	Casting	Honeycomb	Joint	Composite	Miscellaneous	Tension	Compression	Shear	Bearing	Fatigue	Creep	Miscellaneous	None	Unstressed Heating	Stressed Heating	Miscellaneous	None	Heat Treat	Mech. Working	Welding	Brazing	Bonding	Cleaning Method	Surface Finish	Miscellaneous	
High Alloy Steels																															
17-7 PH	1.A.6.6.1	*									*							*										*			2
	1.AG.6.6.2	*						*			*							*							*						2
	1.A.6.6.3	*									*							*					*								2
	1.A.6.6.4	*									*							*				*									2
	1.A.6.6.5	*									*							*					*								3
	1.A.6.6.6	*									*							*						*							3
	1.AG.6.6.7	*						*					*				1 V *	*					*		*						3
	1AG.6.6.8	*						*					*					*					*		*						3
	1.A.6.6.9	*									*							*											*		4
AM357	1.A.6.7.1	*									*							*				*									2
422 Mod.	1.A.6.8.1		*								*							*	*				*								3
AISI 301	1.A.6.9.1	*									*							*											*		3
INVAR	1.A.6.10.1	*									*							*						*							4
AISI 302	1.AG.6.11.1	*									*				*				*						*						4

METALLIC MATERIALS

MASTER DATA INDEX																														
Material	Code	Material Form									Data Type							Environment				Processing Variable									QUARTERLY REPORT
		Sheet and Plate	Bar	Extrusion	Forging	Casting	Honeycomb	Joint	Composite	Miscellaneous	Tension	Compression	Shear	Bearing	Fatigue	Creep	Miscellaneous	None	Unstressed Heating	Stressed Heating	Miscellaneous	None	Heat Treat	Mech. Working	Welding	Brazing	Bonding	Cleaning Method	Surface Finish	Miscellaneous	
Nickel Base Alloys																															
M-252	1.A.7.1.1	*									*							*					*								1
	1.AG.7.1.2	*						*			*				*			*							*						1
	1.A.7.1.3	*	*								*							*	*			*									1
U-500	1.A.7.2.1	*									*							*	*			*									1
Inconel-X	1.AF.7.3.1	*						*									7 V *	*											*	9 V *	2
	1.A.7.3.2	*									*			*				*	*			*									2
	1.A.7.3.3	*									*							*	*		8 V *		*								2
	1.AF.7.3.4	*						*							*		7 V *	*				*									3
	1.A.7.3.5	*													*			*			8 V *	*									3
	1.A.7.3.6	*									*							*	*				*								3
	1.A.7.3.7	*									*				*			*												3 V *	3

7 V Load Deflection

8 V Prestrain

9 V Fasteners

METALLIC MATERIALS

MASTER DATA INDEX																															
Material	Code	Material Form									Data Type							Environment				Processing Variable									QUARTERLY REPORT
		Sheet and Plate	Bar	Extrusion	Forging	Casting	Honeycomb	Joint	Composite	Miscellaneous	Tension	Compression	Shear	Bearing	Fatigue	Creep	Miscellaneous	None	Unstressed Heating	Stressed Heating	Miscellaneous	None	Heat Treat	Mech. Working	Welding	Brazing	Bonding	Cleaning Method	Surface Finish	Miscellaneous	
Nickel Base Alloys																															
Inconel 700	1.A.7.4.1		*								*								*			*									2
René 41	1.A.7.5.1	*									*								*				*								2
	1.A.7.5.2	*									*							*					*								2
	1.A.7.5.3	*									*							*										*			2
	1.AF.7.5.4	*						*					*		*			*												3 V *	3
	1.AG.7.5.5	*									*						2 V *		*						*						4
	1.AG.7.5.6	*									*		*						*						*						4
	1.A.7.5.7	*									*	*				*			*					*							4
Waspalloy	1.A.7.6.1	*									*							*	*			*									3
K Monel	1.A.7.7.1	*									*							*					*	*							4
U-700	2.A.7.8.1	*															17 V *		*			*									4
Electroformed Nickel	1.A.7.9.1	*									*							*					*								4

17 V coef. of expansion

SPECIAL PURPOSE MATERIALS

MASTER DATA INDEX																															
Material	Code	Material Form									Data Type							Environment				Processing Variable									
		Sheet and Plate	Bar	Extrusion	Forging	Casting	Honeycomb	Joint	Composite	Miscellaneous	Tension	Compression	Shear	Bearing	Fatigue	Creep	Miscellaneous	None	Unstressed Heating	Stressed Heating	Miscellaneous	None	Heat Treat	Mech. Working	Welding	Brazing	Bonding	Cleaning Method	Surface Finish	Miscellaneous	QUARTERLY REPORT
Adhesives																															
Narmco 103 **Narmco 108** **FM-47** **Shell 422** **AF-31**	1.BH.4.2.1							*					*					*									*				2
Epon VI	1.BH.4.3.1							*					*					*									*				3
Plastics																															
Conductive & Reflective Resins	3.B.8.1.1								*								[18] *	*				*									4
Epoxy Foams	2.B.8.2.1					*											[17] *		*			*									4
Tooling Resins	5.B.8.3.1					*						*					*		*			*									4
Sandwich																															
Honeycomb-Kraft Paper	1.B.9.1.1						*				*	*						*				*									1

[18] Reflectivity & conductivity measurements

SPECIAL PURPOSE MATERIALS

MASTER DATA INDEX

Material	Code	Material Form: Sheet and Plate	Bar	Extrusion	Forging	Casting	Honeycomb	Joint	Composite	Miscellaneous	Data Type: Tension	Compression	Shear	Bearing	Fatigue	Creep	Miscellaneous	Environment: None	Unstressed Heating	Stressed Heating	Miscellaneous	Processing Variable: None	Heat Treat	Mech. Working	Welding	Brazing	Bonding	Cleaning Method	Surface Finish	Miscellaneous	QUARTERLY REPORT
Transparent Materials																															
Stretched Plex 55	**1.BF.12.1.1**	*												*	*				*			*									4
Plexiglas II	**1.BF.12.2.1**	*												*					*			*									4
Bearings																															
Staking	**1.B.16.1.1**									*							[10] *	*												[11] *	1
Miscellaneous																															
Plaster Parting Agents	**1.B.17.1.1**									*	*							*												[12] *	2

[10] Push Out Load

[12] Bearings

[11] Parting Agent

APPENDIX

Mechanical Property Data Sheets

Thermophysical Properties Data Sheets

Electrical Property Data Sheets

Miscellaneous Property Data Sheets

APPENDIX INDEX

MECHANICAL PROPERTY DATA SHEETS

METALLIC MATERIALS	CODE
Aluminum Base Alloys	
X2020	1.A.1.2.4
	1.AG.1.2.5
	1.A.1.2.6
5456	1.AG.1.8.1
Magnesium Base Alloys	
HK-31	1.A.2.1.3
AZ-63	1.A.2.3.1
FS-1	1.A.2.4.1
Titanium Base Alloys	
Ti-4Al-4Mn	1.A.3.1.3
Ti-5Al-2.5 Sn	1.AG.3.2.5
Ti-6Al-4V	1.AG.3.3.4
Low Alloy Steels (90% Fe or greater)	
5Cr-Mo-V	1.A.5.3.3
	1.A.5.3.4
High Alloy Steels (less than 90% Fe)	
17-7PH	1.A.6.6.9
INVAR	1.A.6.10.1
AISI 302	1.AG.6.11.1

MECHANICAL PROPERTY DATA SHEETS

METALLIC MATERIALS (cont'd)	CODE
Nickel Base Alloys	
René 41	1.AG.7.5.5
	1.AG.7.5.6
	1.A.7.5.7
K-Monel	1.A.7.7.1
Electroformed Nickel	1.A.7.9.1
SPECIAL PURPOSE MATERIALS	
Transparent Materials	
Stretched Plexiglas 55	1.BF.12.1.1
Plexiglas II	1.BF.12.2.1

THERMO-PHYSICAL PROPERTY DATA SHEETS

METALLIC MATERIALS	
Nickel Base Alloys	
U-700	2.A.7.8.1
SPECIAL PURPOSE MATERIALS	
Plastics	
Epoxy Foams	2.B.8.2.1

ELECTRICAL PROPERTY DATA SHEETS

SPECIAL PURPOSE MATERIALS	
Plastics	
Conductive & Reflective Resins	3.B.8.1.1

MISCELLANEOUS PROPERTY DATA SHEETS

SPECIAL PURPOSE MATERIAL	CODE
Plastics	
Epoxy Tooling Resins	5.B.8.3.1

MECHANICAL PROPERTIES OF X2020 ALUMINUM

MATERIAL IDENTIFICATION (COML.)	MATERIAL STATUS
X2020 - T6 Bare	Experimental
HEAT OR BATCH NUMBER	**FORM**
Unavailable	Sheet

PROCESSING CONDITION

See Below

OBJECT OF TEST	RAC DATA REF.
Investigate the effects of various surface treatments on the mechanical properties of bare X2020 sheet	ESRMR 121, dated March 22, 1960

SPECIMEN TYPE

As per Federal Test Method Standard No. 151a, Method 211.1, dated May 6, 1959

TEST METHOD:

As per Federal Test Method Standard No. 151a, 211.1 dated May 6, 1959.

As-received material contains a heat treat scale composed of aluminum oxide with inclusions of cupric oxide and the products of a lithium-water vapor reaction. Removal of this scale will be required to satisfy fabrication processing requirements and to apply a controlled corrosion protective coating. Fabrication processing such as spot welding and adhesive bonding demands a material surface free of scale. The heat treat scale on X2020, although capable of providing corrosion protection, is not controlled at the mill as to composition and thickness.

The test program was conducted along the lines of first removing the as-received scale and then the application of a corrosion protection surface treatment which is, also, capable of acting as a base for paint.

The three phases of the program were as follows:

a. Investigation of a suitable stripper to remove the "as-received" heat treat scale.

b. Investigation of the suitability of anodizing by the chromic acid process per MIL-A-8625A, Type I and the use of chemical film treatment per MIL-C-5541 as corrosion preventive treatments.

c. Investigation of conformance of the protective coating to the corrosion resistance test procedures outlined in the above-mentioned military specifications.

All panels, each 3 inches wide by 8 inches long by .063 inches thick with the length transverse to the rolling direction, were cut from one sheet of bare X2020-T6 aluminum alloy as supplied by the Aluminum Company of America. The composition of the alloy was:

Lithium	Copper	Manganese	Cadmium	Aluminum
1.1%	4.5%	0.5%	0.2%	Balance

The following stripping solutions were used.

a. Turco #2897 - at concentration of 10 oz/gal. of water at room temperature. Panels were immersed for 5-10 minutes followed by rinsing in cold overflowing water.

b. Alcoa Research Laboratory's solution - made up of 100 cc of sulphuric acid and 35 grams of chromic acid added to water to make 1 liter of solution and maintained at 180°F. Panels were immersed for 5 minutes followed in order by a cold water rinse, a 1 minute dip in 20 percent nitric acid solution at room temperature and a cold water rinse.

Surface treatments used were:

a. Anodic coating per specification MIL-A-8625A, Type I - panels were anodized in a 5-10 percent chromic acid solution, pH of 0.7 maintained at 90°F-95°F for 30 minutes at 40 volts.

b. Chemical film coating per specification MIL-C-5541 - panels were treated with Alodine 1000 in accordance with standard RAC shop procedure.

Post surface treatments were:

a. Post anodic - "sealed" panels were rinsed in water at 150°F minimum. "Not sealed" panels were rinsed in water at room temperature.

b. Post chemical film - panels were rinsed in hot (160°F-180°F) water for 15-60 seconds.

The following tests were performed:

1. Corrosion Resistance Tests

Salt spray exposure - panels were subjected to salt spray test conducted in accordance with specification QQ-M-151. The significant surfaces of the panels were inclined approximately 6° from the vertical and the salt fog was approximately 20 percent (by weight) of sodium chloride.

2. Mechanical Property Tests

Tensile, elongation, and yield values were obtained from flat specimens at room temperature.

3. Coating Weight and Thickness

Two (2) anodized panels were submitted to Alcoa Research Laboratories to determine coating thickness and weight.

The results obtained are as follows:

1. Visual examination of panels subjected to salt spray exposure for 240 hours showed that the anodized sealed panels had few or no pits, the anodized unsealed panels had few pits, the stripped, bare panels all were badly pitted.

2. The mechanical property values are listed in accompanying tables.

3. The anodic coating weights and thicknesses obtained by Alcoa are as follows:

Stripper	Surface Treatment	Coating Thickness	Coating Weight
None	Anodized-Not Sealed	.00011"	462 mg/ft^2
Alcoa	Anodized-Not Sealed	.00011"	428 mg/ft^2

Results of panels chemical film treated are not reported because preliminary tests showed that Alodine treatment was not satisfactory for bare X2020.

Conclusion:

X2020 bare aluminum alloys can and should be processed as per specification MIL-A-8625A, Type I. Although the results indicate that the Alcoa stripping solution is less detrimental than the Turco stripping solution (elongation results on stripped, no surface treatment specimens subjected to 240 hours salt spray), either stripping solution will be satisfactory inasmuch as the results obtained on anodized specimens are comparable plus the fact that current policy at RAC calls for primer to be applied to anodized surfaces.

PANELS WITH HEAT TREAT SCALE

Surface Treatment	Salt Spray Exposure - Hrs.	Elongation in 2" - %	Tensile KSI	Yield KSI
None	240	6.5	80.0	75.2
		5.5	80.1	74.3
		4.5	78.6	74.3
		6.0	79.0	74.1
		6.5	80.4	73.7
None		4.8	78.5	72.9
Anodized-Sealed		6.0	78.8	73.4
		7.5	78.9	73.6
		6.0	78.4	72.7
		6.0	79.1	74.0
		6.0	79.5	73.5
Anodized-Sealed		6.0	78.6	72.3
Anodized-Not Sealed		5.0	78.7	72.6
		6.8	81.8	73.4
		6.7	80.8	70.4
		4.5	79.4	73.6
Anodized-Not Sealed	240	5.5	78.6	73.4

PANELS WITH HEAT-TREAT SCALE REMOVED WITH ALCOA STRIPPER

Surface Treatment	Salt Spray Exposure - Hrs.	Elongation in 2" - %	Tensile KSI	Yield KSI
None	None	5.5	79.6	74.0
		5.8	78.2	73.2
		5.7	78.0	69.7
		6.0	79.7	73.0
		6.0	80.2	73.0
	None	5.0	79.6	73.5
	240	3.5	79.4	72.9
		4.0	79.4	72.1
		5.0	79.7	70.1
		5.0	79.6	73.2
		4.5	79.9	72.5
		5.5	80.2	73.6
		4.5	80.0	73.0
None		5.0	80.8	75.4
Anodized-Sealed		7.5	84.5	73.1
		7.0	80.4	73.9
		6.5	79.8	74.5
		5.0	78.5	73.4
		6.5	79.6	73.8
		7.0	79.7	73.8
		6.5	78.5	73.2
		6.0	80.1	73.6
Anodized-Sealed		5.3	80.1	73.0
Anodized-Not Sealed		5.0	81.0	75.0
		5.0	80.6	74.9
		6.5	79.2	73.0
		4.0	78.0	72.9
		5.5	79.3	73.5
		5.5	78.8	74.0
		6.0	80.4	74.5
		5.5	79.1	73.1
Anodized-Not Sealed	240	4.5	79.1	72.6
Anodized-Sealed	None	7.5	81.0	77.1
Anodized-Sealed	None	6.5	81.5	76.6
Anodized-Sealed	None	6.0	81.1	76.4

PANELS WITH HEAT-TREAT SCALE REMOVED WITH TURCO STRIPPER

Surface Treatment	Salt Spray Exposure - Hrs.	Elongation in 2" - %	Tensile KSI	Yield KSI
None	None	6.0	79.4	73.9
		7.5	79.9	73.1
		7.5	79.7	73.2
		5.0	79.1	76.5
		4.0	78.8	74.3
	None	6.0	78.2	73.0
	240	3.0	79.1	73.0
		2.5	78.2	72.5
		2.0	78.5	72.7
		4.0	78.2	72.1
		5.5	78.0	72.6
		1.0	76.2	72.4
		1.0	76.9	73.6
None		2.0	77.7	73.0
Anodized-Sealed		4.5	79.3	73.0
		6.0	78.9	72.9
		5.5	79.1	73.7
		5.8	79.2	73.0
		6.0	79.2	72.6
		6.5	79.5	73.1
		7.0	79.7	74.2
		7.5	79.9	73.9
Anodized-Sealed		8.0	79.3	73.5
Anodized-Not Sealed		6.5	78.5	74.4
		6.0	79.6	73.5
		7.0	80.7	75.1
		7.5	78.9	73.0
		5.5	79.8	73.4
		7.5	78.8	73.6
		6.0	79.1	73.5
		6.5	80.2	74.6
Anodized-Not Sealed	240	6.0	78.8	74.5
Anodized-Sealed	None	7.0	81.2	76.8
Anodized-Sealed	None	6.0	81.1	76.1

CODE: 1.AG.1.2.5

PAGE 1 OF 1

MECHANICAL PROPERTIES OF X-2020

MATERIAL IDENTIFICATION (COML.)	MATERIAL STATUS
X2020-T6 Aluminum Alloy	Semi-Production
HEAT OR BATCH NUMBER	**FORM**
Unavailable	.064 Sheet

PROCESSING CONDITION

T6 - Solution Treated and Artificially Aged

OBJECT OF TEST	RAC DATA REF.
To Evaluate Resistance Spot Welds in X2020-T6 Aluminum Alloy	M.R. Report 57-100-1

SPECIMEN TYPE

Single Spot Shear Specimens Per MIL-W-6858A, 9 July 1957, Tension Pullout Specimens Per MIL-W-4994, 28 October 1955, or Equivalent.

TEST METHOD: Single Spot Shear and Tension Pullout Specimens Tested in Accordance With MIL-W-6858A, 9 July 1957, and MIL-W-4994, 28 October 1955, Respectively.

Shear Strength (lbs.)		Tension Pullout Strength (lbs.)
1622	1595	620
1560	1554	610
1598	1591	610
1520	1584	615
1586	1606	620
		615 Average
1595	1553	
1582	1620	
1534	1589	
1606	1584	
1652	1595	
	1586 Average	

MECHANICAL PROPERTIES OF X2020 ALUMINUM

CODE: 1.A.1.2.6

MATERIAL IDENTIFICATION (COML.)	MATERIAL STATUS
X2020 (Bare)	Experimental
HEAT OR BATCH NUMBER	**FORM**
Unavailable	.063 Sheet

PROCESSING CONDITION

-T6 Heat Treated and Aged

OBJECT OF TEST	RAC DATA REF.
To evaluate the mechanical properties of X2020 at Room Temperature	ESRMR 157 Dated June 2, 1960

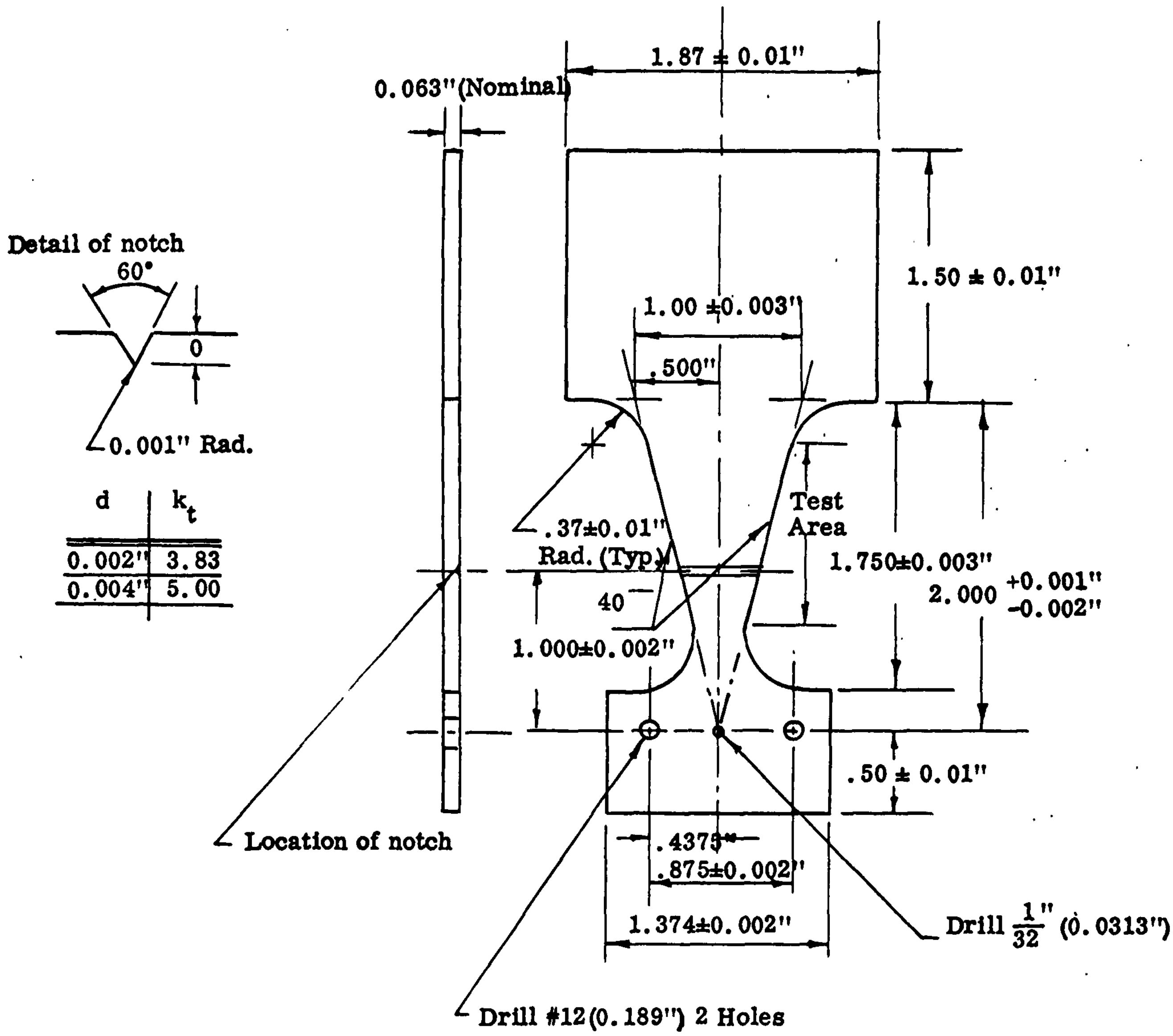
SPECIMEN TYPE

Tension-Std. 0.5" wide sheet specimen as per ARTC-13-T-1 June 1959
Compression-Std. 1 x 3 sheet specimen as per ARTC-13-C-1 July 1957
Flexure Fatigue and axial fatigue specimens - see below.

TEST METHOD:

Tensile Tests - as per Fed. Test Std. 1519 Method 211.1 (May 1959)
Compression Tests - as per ARTC-13-C-1. Sheet specimens were laterally supported during tests. Strains were measured with an extensometer having a 2" gage length.
Flexure fatigue specimens, illustrated on page 2, were tested in a Krouse Testing Machine at 1000 cpm. Both notched and unnotched specimens were evaluated.
Axial fatigue specimens, illustrated on page 3, were tested in a Sonntag SF-1U Testing Machine at 1800 cpm. Both notched and unnotched specimens were evaluated at a stress ratio of R=0.10.

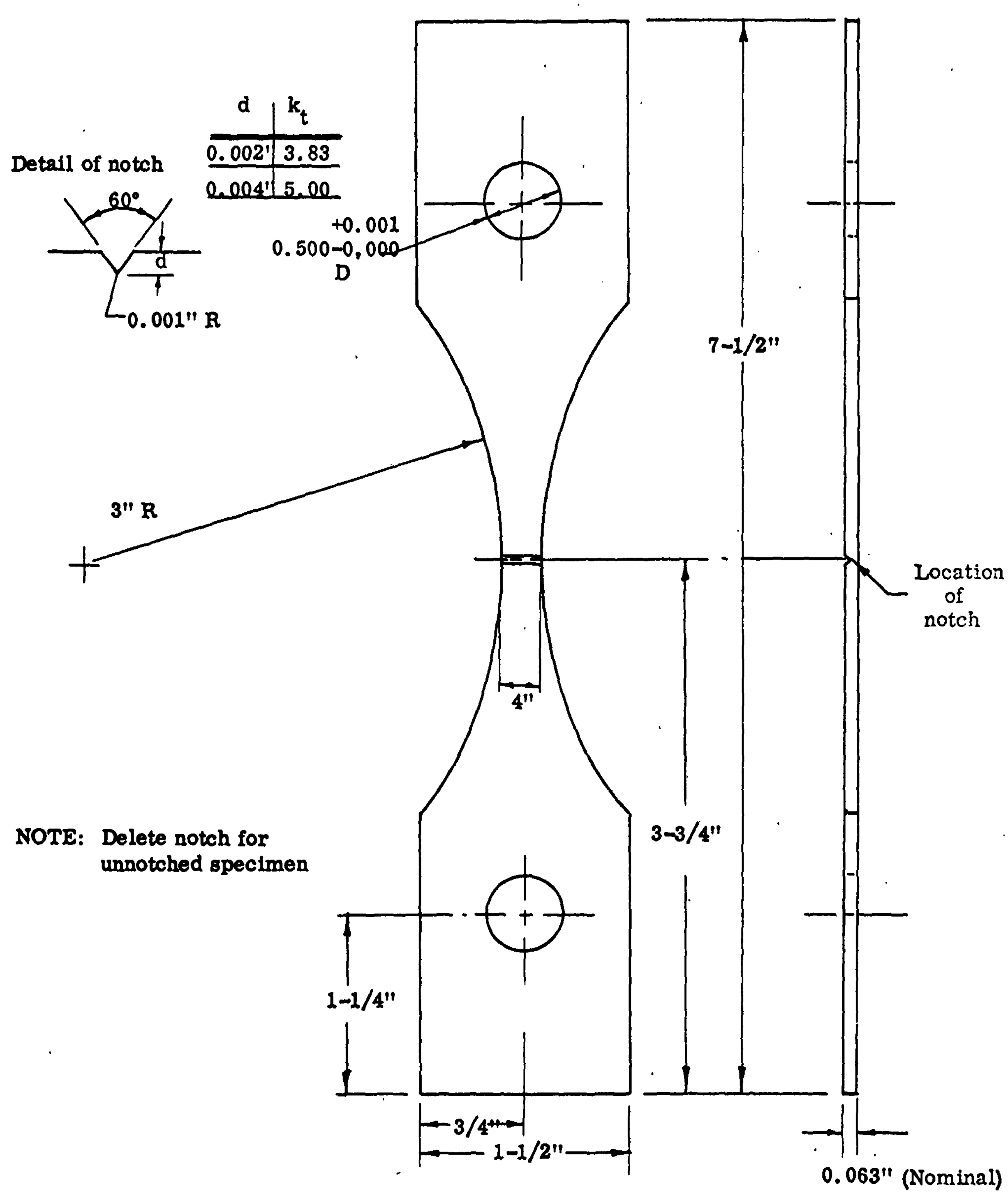
Specimen blanks were sheared to approximate sizes, and the static tension, tension fatigue and flexural fatigue specimens were stamped out to final size and edges polished to RMS40 surface finish. The notched specimens were placed on the bed of a vertical miller, clamped to the bed, and the notch produced by milling with a Brown and Sharpe double angle miller, ground to a 0.001 inch radius. The radius of the miller was checked before and after milling of the notches, as were the depths and radii of notches milled in specimens selected at random. This was accomplished by examination of the quantities in question on an optical comparator at a magnification of 100X. The reduced sections were hand polished to RMS40 parallel to the long axis of the specimen to eliminate the role of random defects. Compression test specimens were sheared to approximate dimensions, milled to finished size and hand polished as above.



d	k_t
0.002"	3.83
0.004"	5.00

NOTE: Delete notch for unnotched specimen

Flexural Fatigue Specimen (Notched)



Tension-Tension Fatigue Specimen

ROOM TEMPERATURE TENSILE TESTS

Material Orientation		Ultimate ksi	.2% Yield ksi	% Elong in 2"	Modulus ksi
Longitudinal		79.6	75.2	7.5	10420.
		80.4	75.6	8.0	11400.
		80.0	74.9	7.5	11860.
	Avg	80.0	75.2	7.7	11230.
Transverse		77.6	71.0	6.5	11610.
		77.8	70.5	4.5	11220.
		77.7	71.2	7.5	10470.
	Avg	77.7	70.9	6.2	11100.

ROOM TEMPERATURE COMPRESSION TESTS

Material Orientation		.2% Yield ksi	Modulus ksi
Longitudinal		87.1	11050.
		84.2	11140.
		83.3	11940.
	Avg	84.9	11380.
Transverse		85.4	12400.
		90.2	10620.
		87.3	11730.
	Avg	87.6	11580.

ROOM TEMPERATURE FLEXURE FATIGUE TESTS

UNNOTCHED SPECIMENS

Material Orientation		Maximum Stress (ksi)	Cycles to Failure
Longitudinal		40	34300
		40	13600
	Avg		23950
		30	123000
		30	82600
	Avg		102500
		20	74600
		20	94900
	Avg		84750
		15	1318100
		15	1259300
	Avg		1288700
		10	3857800*
	Avg		3857800
Transverse		40	10900
		40	13500
	Avg		12200
		30	60700
		30	62500
	Avg		61600
		20	219700
		20	268900
	Avg		244300
		15	5846700
	Avg		5846700

*Specimen did not fail

ROOM TEMPERATURE FLEXURE FATIGUE (NOTCHED) TEST
NOTCHED SPECIMENS

Material Orientation	Specimen Number	Maximum Stress (ksi)	Cycles to Failure	Comments
Longitudinal		40	2700	K_t =3.83
		40	1500	
	Avg.		2100	
		30	10200	
		30	5900	
	Avg.		6050	
		20	19700	
		20	30800	
	Avg.		25250	
Transverse		40	8400	K_t =3.83
		40	1700	
	Avg.		5050	
		30	4100	
		30	4500	
	Avg.		4300	
		20	10300	
		20	43600	
	Avg.		26950	
Longitudinal		40	2800	K_t =5.00
		40	3000	
	Avg.		2900	
		30	4500	
		30	11300	
	Avg.		7900	
		20	29300	
		20	29600	
	Avg.		29450	
Transverse		40	2200	K_t =5.00
		40	1400	
	Avg.		1800	
		30	8300	
		30	6200	
	Avg.		7250	
		20	22500	
		20	21200	
	Avg.		21850	

ROOM TEMPERATURE AXIAL FATIGUE TESTS
UNNOTCHED SPECIMENS

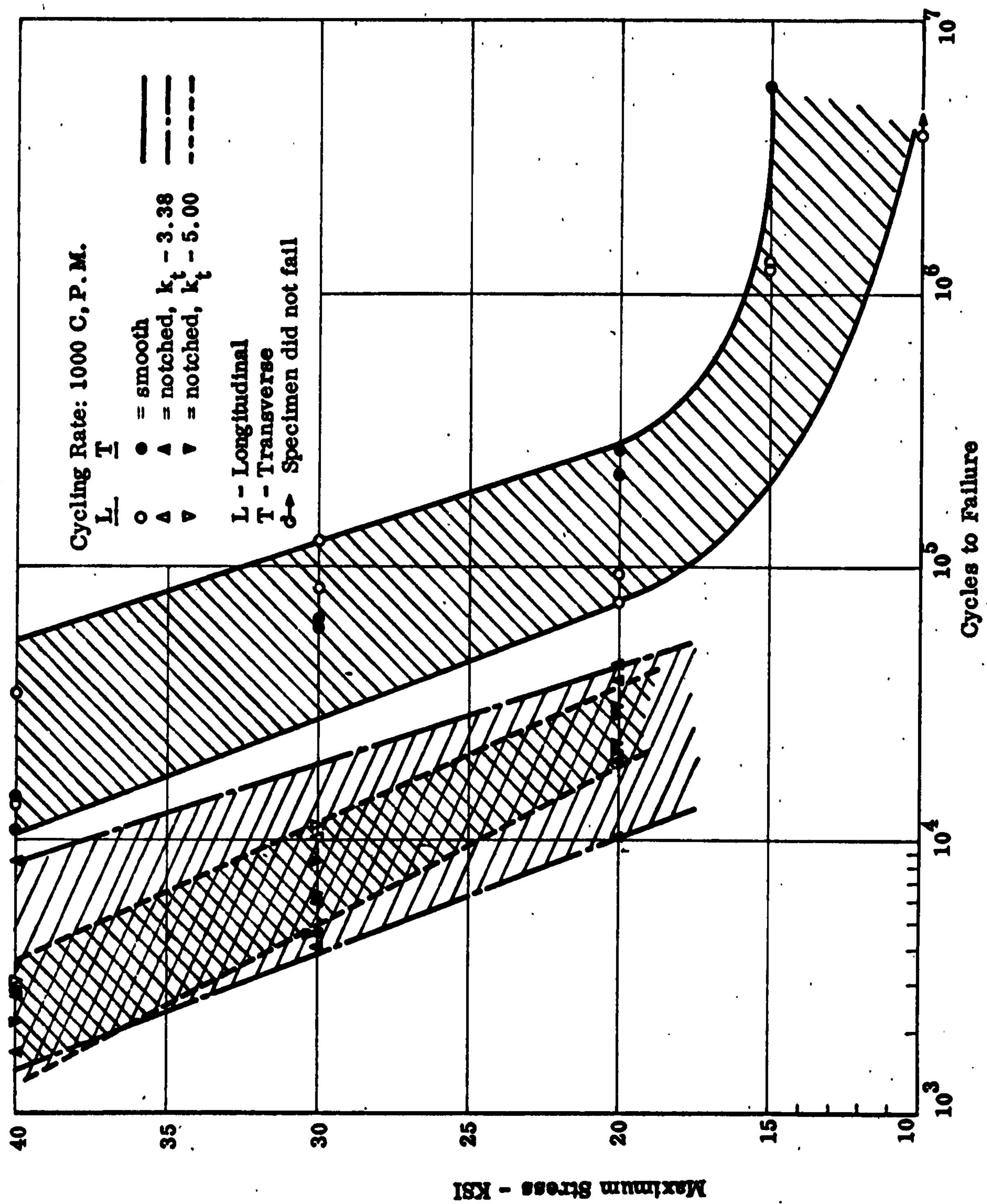
Material Orientation	Specimen Number	Maximum Stress (ksi)	Minimum Stress (ksi)	Cycles to Failure	
Longitudinal		40	4	156000	
		40	4	279000	
		40	4	207000	
		40	4	99000	
		40	4	1866000	(1)
	Avg.			521400	
Transverse		40	4	913000	(2)
		40	4	877000	
		40	4	565000	
		40	4	282000	
		40	4	762000	
	Avg.			679800	

(1) Failed through upper loading hole.

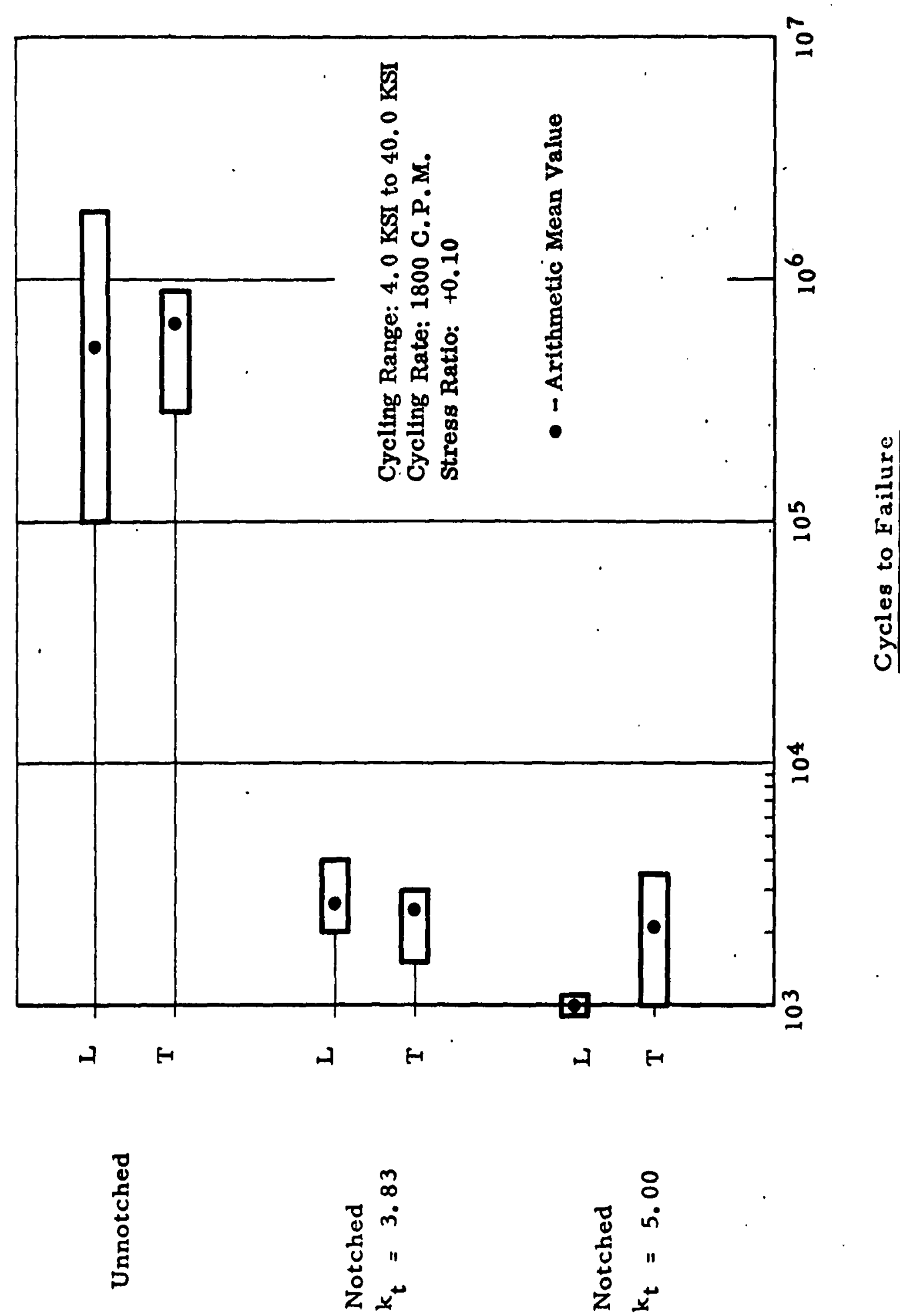
(2) Failed simultaneously through lower loading hole and reduced section.

ROOM TEMPERATURE AXIAL FATIGUE TESTS
NOTCHED SPECIMENS

Material Orientation	Specimen Number	Maximum Stress (ksi)	Minimum Stress (ksi)	Cycles to Failure	Comments
Longitudinal		40	4	4000	K_t =3.83
		40	4	2000	
		40	4	2000	
	Avg.			2667	
Transverse		40	4	3000	K_t =3.83
		40	4	3000	
		40	4	1500	
	Avg.			2500	
Longitudinal		40	4	1000	K_t =5.00
		40	4	1000	
		40	4	1000	
	Avg.			1000	
Transverse		40	4	1000	K_t =5.00
		40	4	2000	
		40	4	3500	
	Avg.			2167	



Comparison of Flexure Fatigue Data



Comparison of Axial Fatigue Data

MECHANICAL PROPERTIES OF 5456 ALUMINUM

MATERIAL IDENTIFICATION (COML.)	MATERIAL STATUS
5456-H321 Aluminum Alloy	Production
HEAT OR BATCH NUMBER	**FORM**
117-615	.250 Inch Sheet

PROCESSING CONDITION

H-321 (Strain Hardened and Stabilized)

OBJECT OF TEST	RAC DATA REF.
To Evaluate Fusion Welds in 5456-H321 Aluminum Alloy.	M.R. Report 60-91-1

SPECIMEN TYPE

Standard Sheet Metal Tensile And Bend Test Specimens Per Federal Test Method Standard No. 151a dated May 6, 1959.

TEST METHOD:

Standard Sheet Metal Tensile and Bend Test Specimens Tested in Accordance With Federal Test Method Standard No. 151a dated May 6, 1959.

BASE METAL TENSILE TESTS

	Ultimate Tensile Strength ksi	0.2% Offset Yield Strength ksi	Percent Elongation in 2"	Location of Failure	Notes
	54.1	33.8	13.5	-	(1)
	53.4	33.8	13.5	-	(1)
	53.7	33.3	13.5	-	(1)
	53.6	33.2	13.0	-	(1)
	53.8	33.9	11.5	-	(1)
	53.6	34.0	13.0	-	(1)
Average	53.7	33.7	13.0		

SINGLE PASS WELD TENSILE TESTS

1. Welds Transverse to Strain Axis, Weld Reinforcement Ground Flush

	Ultimate Tensile Strength ksi	0.2% Offset Yield Strength ksi	Percent Elongation in 2"	Location of Failure	Notes
	45.2	22.8	9.0	W	(2), (4)
	45.8	23.7	9.5	W	(2), (4)
	46.1	23.7	9.5	W	(2), (4)
	43.8	26.5	9.0	W	(2), (4)
	43.4	24.6	9.0	W	(2), (4)
	45.6	23.4	10.0	W	(2), (4)
	43.1	25.8	9.5	W	(2), (4)
	43.4	24.4	9.5	W	(2), (4)
	42.1	23.1	7.0	W	(2), (4)
	41.3	-	9.5	W	(2), (4)
	43.7	22.9	10.5	W	(2), (4)
	43.1	22.2	10.5	W	(2), (4)
	43.3	22.9	10.0	W	(2), (4)
	43.8	22.8	10.0	W	(3), (4)
	43.5	21.9	10.0	W	(2), (4)
Average	43.8	23.6	9.5		

2. Welds Transverse to Strain Axis, Weld Reinforcement Intact (See Note 5 for all specimens)

	44.9	-	7.0	WT	(2), (4)
	47.0	21.0	9.0	WT	(2), (4)
	46.8	22.1	9.0	WT	(2), (4)
	48.4	24.3	8.5	WT	(2), (4)
	47.5	22.3	9.0	WT	(2), (4)
	48.2	21.8	10.0	WT	(2), (4)
	47.7	21.3	9.0	WT	(2), (4)
	49.2	-	10.0	WT	(2), (4)
	49.7	25.6	9.5	WT	(2), (4)
	47.4	21.1	8.0	WT	(2), (4)
Average	47.7	22.4	8.9		

SINGLE PASS WELD TENSILE TESTS - CONT'D

3. Weld Parallel to Strain Axis, Weld Reinforcement Ground Flush

	Ultimate Tensile Strength ksi	0.2% Offset Yield Strength ksi	Percent Elongation in 2"	Location of Failure	Notes
	44.4	19.4	22.5	-	(2), (4)
	44.1	18.8	26.5	-	(2), (4)
	44.3	19.3	25.0	-	(2), (4)
	43.6	18.9	26.5	-	(2), (4)
	44.2	19.0	24.0	-	(2), (4)
Average	44.1	19.1	24.9		

4. Weld Parallel to Strain Axis, Weld Reinforcement Intact

	Ultimate Tensile Strength ksi	0.2% Offset Yield Strength ksi	Percent Elongation in 2"	Location of Failure	Notes
	55.6	23.5	17.0	NMT	(6)
	54.3	23.4	14.0	NMT	(6)
	50.8	-	9.0	NMT	(6)
	57.1	24.3	20.0	NMT	(6)
	57.3	23.7	24.5	NMT	(6)
Average	55.0	23.7	16.9		

Notes: (1) Specimens showed little or no visible reduction in area, but failed on a plane making a 45° angle with the specimen face.

(2) Specimen showed visible reduction in area, not measured, and failed along a plane making a 45° angle with the specimen face.

(3) Specimen showed visible reduction in area, with cup-cone type failure.

(4) Specimen showed mottled surface at strained weld deposit.

(5) Strength based on measured area adjacent to weld.

(6) Strengths listed based on nominal thickness of base material, although actual cross-section was increased by presence of weld reinforcement.

W = Weld   WT = Weld toe, fusion line   NMT = Failure outside middle third of gage length

DOUBLE PASS WELD TENSILE TESTS

1. Welds Transverse to Strain Axis, Weld Reinforcements Ground Flush

	Ultimate Tensile Strength ksi	0.2% Offset Yield Strength ksi	Percent Elongation in 2"	Location of Failure	Notes
	44.5	25.1	10.0	W	(1), (2)
	44.8	25.3	10.5	W	(1), (2)
	44.6	24.6	10.5	W	(1), (2)
	44.7	23.5	10.0	W	(1), (2)
	44.4	25.7	9.5	W	(1), (2)
	43.5	22.3	8.0	W	(1), (2)
	44.3	24.7	9.5	W	(1), (2)
	44.2	24.7	10.0	W	(1), (2)
	44.2	23.9	9.5	W	(1), (2)
	44.4	23.0	10.5	W	(1), (2)
Average	44.4	24.3	9.8		

2. Welds Transverse to Strain Axis, Weld Reinforcements Intact

	Ultimate Tensile Strength ksi	0.2% Offset Yield Strength ksi	Percent Elongation in 2"	Location of Failure	Notes
	47.9	24.2	10.5	WT	(2), (3)
	47.4	27.0	10.5	WT	(2), (3)
	48.1	26.1	12.0	WT	(2), (3)
	48.5	27.1	12.0	WT	(2), (3)
	49.8	27.9	12.0	WT	(2), (3)
	46.3	26.6	10.0	WT	(2), (3)
	44.9	27.1	8.5	HAZ	(2), (4)
	48.3	26.3	10.0	WT	(2), (3)
	46.2	26.4	10.0	HAZ	(2), (4)
	46.9	25.6	10.0	WT	(2), (3)
Average	47.4	26.4	10.5		

Notes: (1) Specimen showed visible reduction in area, not measured, with fracture occurring along a plane making a 45° angle with the specimen face.

(2) Specimen showed a mottled surface at the weld deposit.

(3) Specimen failed along fusion line with visible reduction in area.

(4) Specimen failure initiated at fusion line and propagated into heat-affected zone at 45° angle with specimen face, with visible reduction in area not measured.

W = Weld   HAZ = Heat affected zone   WT = Weld toe - fusion line

GUIDED FACE BEND TEST RESULTS

All specimens ground flush prior to testing.
All specimens 1.0 ± .1 inches wide.

Parent Metal - No Weld

Thickness	Mandrel Diameter (inches)	Bend Radius "T"	Bend Angle	Remarks
.259	.985	1.9	180°	satisfactory
.259	.985	1.9	180°	satisfactory, specimen edges sharp
.259	.875	1.7	180°	satisfactory
.259	.875	1.7	180°	edges sharp, crack initiated at edge
.259	.875	1.7	76°	edges sharp, failed
.259	.755	1.45	84°	edges sharp, failed
.259	.755	1.45	180°	satisfactory
.259	.705	1.35	55°	failed

Minimum Bend Radius = 1.7 T

Longitudinal Bends - (Bending Transverse to Welding Direction)

A. C. - Single Pass Welds

.246	.985	2	180°	satisfactory
.248	.875	1.75	180°	satisfactory
.247	.755	1.53	180°	satisfactory
.250	.705	1.41	86°	failed, defect in weld
.246	.705	1.44	180°	crack in base metal
.246	.705	1.44	180°	crack in base metal

Minimum Bend Radius - 1.5 T

D. C. - Double Pass Welds

.236	.985	2.09	180°	satisfactory
.238	.875	1.83	180°	satisfactory
.234	.755	1.61	180°	satisfactory
.228	.705	1.54	180°	satisfactory
.241	.705	1.46	180°	satisfactory

Minimum Bend Radius - less than 1.5 T

GUIDED FACE BEND TEST RESULTS - CONT'D

Transverse Bends - (Bending Parallel to Welding Direction)

A. C. - Single Pass Welds

Thickness	Mandrel Diameter (inches)	Bend Radius "T"	Bend Angle	Remarks
.239	.985	2.06	180°	satisfactory
.240	.985	2.05	180°	small cracks, edge of weld
.239	.985	2.06	180°	small cracks, edge of weld
.239	.875	1.83	180°	small cracks in weld
.235	.875	1.86	180°	satisfactory
.229	.875	1.91	80°	defect in weld
.232	.875	1.88	180°	small cracks in weld
.235	.875	1.86	180°	small cracks in weld
.241	.875	1.82	180°	satisfactory
.240	.875	1.82	180°	cracked full length of weld

Minimum Bend Radius - Greater than 2.0 T

D. C. - Double Pass Welds

.239	.985	2.06	180°	2 small cracks in weld
.240	.875	1.82	180°	satisfactory
.233	.875	1.87	180°	satisfactory
.237	.875	1.85	180°	small cracks in weld
.233	.875	1.87	180°	satisfactory
.243	.875	1.80	180°	satisfactory
.234	.875	1.87	180°	satisfactory
.244	.875	1.79	180°	satisfactory
.242	.875	1.80	120°	failed at edge of weld
.245	.875	1.78	68°	failed at edge of weld

Minimum Bend Radius - Greater than 2.0 T

MECHANICAL PROPERTIES OF HK31 MAGNESIUM

MATERIAL IDENTIFICATION (COML.) HK31-24	MATERIAL STATUS Production
HEAT OR BATCH NUMBER See Data Below	FORM Sheet

PROCESSING CONDITION

Strain hardened and partially annealed as per MIL-M-26075

OBJECT OF TEST To certify vendor material for RAC proprietary material specification.	RAC DATA REF. Quality Control Materials Laboratory Acceptance Files

SPECIMEN TYPE

Flat tensile specimens conforming to Federal Test Method 151, Method 211, Type F2, cut parallel to the rolling direction.

TEST METHOD:

The elevated temperature tension tests were conducted in accordance with Federal Test Method 151, Method 211. Two test specimens were prepared from each sheet of material. Each specimen was subjected to short time heating (30 minutes) and tested at elevated temperature. One specimen was tested at 500°F $\pm$ 5° and the other at 600°F $\pm$5°. The tests were conducted at a strain rate of 0.005 $\pm$ 0.002 inch per inch per minute to the yield strength. Beyond the yield strength the rate of strain was increased to 0.11 to 0.14 inch per inch per minute of cross head travel.

NOTE: Tensile yield strenth was not recorded as it is not required by RAC specification.

DATA:

Gage .025 - Vendor: Dow

Vendor Test Report (Room Temp.)

Lot #	T.S. KSI	T.Y.S. KSI	Elong.
319001	40.0/ 40.2	33.1/ 33.1	6.5/ 8.5

Republic Test Reports

500°F T.S. KSI	500°F Elong.	600°F T.S. KSI	600°F Elong.
23.8	16.5	15.3	20.0
22.7	17.0	15.6	20.0
24.4	19.5	16.5	20.0
22.5	14.5	16.7	18.0
23.5	17.5	17.5	21.5
21.3	17.5	16.8	21.5
24.6	13.0	18.3	19.0
24.6	22.5	19.0	20.0
24.2	15.5	19.2	22.0
25.0	15.0	17.5	25.0
22.5	20.0	19.6	27.5
22.1	20.0	18.8	21.0
22.1	19.0	20.0	18.0
21.7	16.5	17.9	20.5
22.5	21.5	18.3	17.5
20.8	18.5	19.2	21.0
22.9	14.5	19.4	23.0
20.4	21.5	20.0	25.0
21.7	17.5	17.4	20.5
22.5	17.5	17.5	17.5
17.6	17.5	17.9	19.5
19.2	20.5	16.6	16.5
22.3	13.5	17.7	16.5
19.3	14.5	15.7	19.5
20.0	13.5	16.5	22.5
19.8	13.5	17.1	22.0
19.6	16.0	14.2	21.5
20.1	14.0	15.9	18.5
20.2	12.5	17.1	10.0
20.4	14.5	15.0	15.0
21.0	19.0	15.4	24.0
21.8	20.0	17.9	11.5
21.3	21.0	17.2	15.5
20.2	16.0	14.8	19.0
20.7	17.5	15.9	20.5
19.3	19.0	19.5	17.0
19.9	15.0	15.9	16.0
21.6	11.5	16.9	15.5
20.8	12.5	17.5	14.5
21.3	13.0	18.3	14.0
20.8	11.5	19.2	13.0
20.4	12.0	18.3	14.5
19.8	12.5	25.8	16.0

Gage .025 (Cont'd)

	Vendor Test Report (Room Temp.)			Republic Test Reports			
				500°F		600°F	
Lot #	T.S. KSI	T.Y.S. KSI	Elong.	T.S. KSI	Elong.	T.S. KSI	Elong.
319001				21.5	13.0	21.7	14.0
				22.1	13.5	20.8	17.0
				20.0	12.5	22.0	15.0
				21.0	12.0	20.6	14.0
				22.5	14.0	20.2	17.5
				21.6	16.0	17.7	13.5
				20.6	13.0	16.8	11.5
				21.4	11.0	16.7	9.5
				21.3	12.5	17.5	11.0
319004	38.8/ 38.9	31.1/ 31.9	6.0/ 6.5	22.8	18.5	17.5	21.5
				20.8	16.5	17.7	14.5
				23.8	15.0	15.9	22.5
				23.8	15.0	17.7	15.0
				24.2	17.0	17.6	14.5
				24.8	12.0	22.4	15.0
				22.5	18.5	20.5	14.0
				23.1	15.5	21.1	15.5
				23.1	12.0	20.1	19.0
				23.6	11.5	20.2	19.0
				23.6	13.5	20.8	16.0
				22.6	14.0	19.7	14.0
				22.8	16.5	20.8	18.0
				22.6	14.0	21.3	15.0
				23.4	12.0	20.8	16.0
				21.8	12.5	20.3	15.5
				21.7	9.0	19.4	15.0
				23.6	13.0	17.5	20.0
				24.2	10.5	16.0	17.0
				24.2	9.0	17.6	16.0
				22.1	8.0	18.9	16.0
				24.6	11.0	17.9	15.0
				24.2	9.5	17.6	15.0
				23.8	10.0	18.0	15.5
				24.6	10.0	18.5	17.0
				25.2	9.0	19.9	17.5
				25.6	10.5	19.8	19.0
				24.6	9.5	18.7	19.5
				23.3	10.0	20.2	16.5
				21.4	16.5	19.8	13.0
				21.1	17.0	21.3	15.0
				21.0	15.0	19.2	14.5
				21.5	15.0	20.4	15.0
				23.3	16.0	19.7	15.5
				21.0	15.0	20.0	15.5

Gage .025 (Cont'd)

	Vendor Test Report (Room Temp.)			Republic Test Reports			
				500°F		600°F	
Lot #	T.S. KSI	T.Y.S. KSI	Elong.	T.S. KSI	Elong.	T.S. KSI	Elong.
319004				22.7	12.5	18.7	16.5
				24.0	14.5	19.3	15.5
				26.0	8.5	19.8	13.0
				27.1	7.5	18.5	15.5
				24.6	10.0	18.0	15.0
				24.0	13.0	18.3	14.0
				22.6	14.0	20.5	17.5
				22.5	10.0	19.0	13.5
				24.0	9.0	18.0	17.0
				25.2	9.2	21.3	15.5
				21.7	14.5	16.7	20.0
				23.3	15.5	17.9	19.0
				21.5	14.0	18.3	10.5
				21.4	16.5	17.9	19.5
				23.8	18.0	18.3	18.0
				22.0	21.0	18.1	17.5
				23.0	21.0	16.8	26.5
				23.2	12.0	18.6	16.5
				22.0	19.5	18.4	17.0
				22.6	16.0	18.0	16.0
				23.8	17.0	17.6	17.0
				20.8	2.0	18.3	17.0
C09020	37.8/ 37.8	29.3/ 29.4	17.5/ 18.5	19.7	26.5	16.5	25.5
				18.8	23.5	14.8	31.0
				17.4	26.5	16.2	28.0
				18.5	27.5	14.0	30.0
				18.7	29.0	16.5	38.0
				19.7	29.0	16.3	32.0
				17.9	28.5	16.9	33.0
				18.0	38.5	15.8	37.0
				17.5	30.0	17.5	34.0
				16.8	32.5	16.2	30.0

Gage .040

	Vendor Test Report (Room Temp.)			Republic Test Reports			
				500°F		600°F	
Lot #	T.S. KSI	T.Y.S. KSI	Elong.	T.S. KSI	Elong.	T.S. KSI	Elong.
C09009	37.9/ 38.1	30.5/ 30.8	14.5/ 15.0	21.2	22.5	17.8	21.5
				21.4	21.5	17.2	24.5
				21.1	16.5	17.1	21.0
				20.7	16.0	18.5	21.0
				19.7	18.5	18.5	21.0
				17.5	22.0	19.0	27.0
				23.2	20.0	20.1	19.0
				15.3	18.5	18.4	23.5
				18.1	32.0	18.5	24.2
619008	38.1/ 38.1	31.3/ 31.6	14.0/ 14.5	20.8	28.5	17.7	29.5
				20.6	28.5	17.1	25.0
				19.9	29.5	16.8	33.0
				21.1	21.5	16.1	23.5
				20.2	28.0	17.0	33.0
				20.8	25.0	17.5	29.0
				22.9	29.5	16.9	29.5
				18.9	29.5	16.2	33.5
				16.2	23.0	17.7	24.5
				22.3	24.5	17.0	24.5
797005	41.1/ 41.3	33.7/ 35.8	6.0/ 6.5	--	—	19.6	21.5
				—	—	22.0	20.0
A99006	38.4/ 38.5	31.9/ 32.3	7.5/ 10.0	22.1	20.5	20.8	21.5
A99021	38.8/ 39.2	31.9/ 32.3	7.5/ 10.0	25.0	—	18.2	—

Gage .050

	Vendor Test Report (Room Temp.)			Republic Test Reports			
				500°F		600°F	
Lot #	T.S. KSI	T.Y.S. KSI	Elong.	T.S. KSI	Elong.	T.S. KSI	Elong.
799002	38.3/ 38.4	29.5/ 30.6	9.5/ 10.1	--	--	17.7	20.0
				22.0	--	19.0	--
				21.1	22.0	17.1	16.0
A99005	38.4/ 38.8	29.8/ 30.9	9.0/ 11.5	23.6	18.0	16.5	23.0
				14.3	17.0	19.5	17.0
				15.3	15.5	18.5	15.5

Gage .063

	Vendor Test Report (Room Temp.)			Republic Test Reports			
				500°F		600°F	
Lot #	T.S. KSI	T.Y.S. KSI	Elong.	T.S. KSI	Elong.	T.S. KSI	Elong.
599013	38.5/ 38.8	26.6/ 28.8	7.5/ 8.5	23.7	—	18.0	—
A09006	33.2/ 33.4	30.9/ 31.3	22.4/ 23.6	20.4	21.5	17.0	23.5
				20.9	17.5	16.5	26.0
				22.2	25.5	19.0	23.0
				22.9	22.5	18.5	22.5
				20.6	23.0	19.2	20.0
				21.7	22.5	19.3	21.5
				20.7	23.5	17.5	23.5
				21.6	22.0	17.8	23.0
				22.7	22.0	19.4	21.0
				20.3	22.0	18.6	22.5
				23.1	32.0	19.6	21.0
				22.8	22.5	19.3	21.0
609046	39.3/ 39.5	26.4/ 26.9	5.5/ 8.0	21.6	18.0	19.2	21.5
				21.9	15.5	17.5	22.0
				21.0	17.5	17.3	23.0
				27.9	14.0	18.7	21.0

MECHANICAL PROPERTIES OF AZ63 CAST MAGNESIUM

CODE: 1.A.2.3.1	PAGE 1 OF 41

MATERIAL IDENTIFICATION (COML.) AZ63	MATERIAL STATUS Production
HEAT OR BATCH NUMBER Not available	FORM Cast Plate
PROCESSING CONDITION See below	
OBJECT OF TEST Evaluate mechanical properties of different tempers	RAC DATA REF. ERM 14, dated July 30, 1956
SPECIMEN TYPE As per Federal Test Method Standard No. 151a, Method 211.1, dated May 6, 1956	

TEST METHOD:

Tests were conducted on cast AZ63 plate obtained from the Osbrink Manufacturing Company. Four different tempers and four different thicknesses were checked. The four tempers were:

AC As-cast
T2 As-cast and stabilized
T4 Heat treated
T6 Heat treated and aged

In each temper, plates were made in nominal thicknesses of 3/32", 3/16" and 3/4".

X-rays were made of each plate and specimen locations were noted. Strips were cut from each plate and identified as to location and x-ray number.

Tensile coupons were machined, leaving the surface of each specimen in the as-cast condition. All specimens were then measured for area determination at five separate points within the 2" gage length: at the center, 1/2" and 1" on either side of the center.

Testing was done at room temperature on the Baldwin-Lima-Hamilton Universal Testing Machine of 50,000 pounds capacity for the nominal 3/32", 3/16", and 3/8" thick specimens. The 3/4" thick specimens would not fit the grips on this machine and were tested in the Baldwin-Lima-Hamilton Universal testing machine of 60,000 pounds capacity. On all specimens, a recording extensometer was attached across the gage length to obtain load-strain curves for determination of the tensile yield point (.2% offset). All samples did not fail within the 2" gage marks. However, a load-strain record was still obtained on all samples, and yield points determined where an accurate area could be measured. Where this was not possible, no values are given and a retest was not made.

X-rays were made on each of the plates for the purpose of specimen orientation and determination of soundness. The following comments were reported:

X-RAY IDENTIFICATION CHART

Thickness	Temper	X-Ray Serial #	Comments
3/32	T4	169495	Medium micro shrinkage throughout.
3/32	T6	169496	Heavy sponge micro in 2 areas approximately 1" square each. Segregation, higher density inclusions, small concentration of blow holes and one area miss run.
3/32	T2	169497	Medium micro shrinkage. One area of sponge micro approximately 2" square. Segregation and one cold shut.
3/32	AC	169498	Medium micro shrinkage throughout.
3/16	T4	169499	Medium to heavy micro shrinkage throughout. High density inclusions.
3/16	T6	169500	Medium to heavy micro shrinkage throughout. High density inclusions.
3/16	T2	169501	Medium to heavy micro shrinkage throughout.
3/16	AC	169502	Medium to heavy micro shrinkage throughout.
3/8	T4	169503	Two areas on either side of plate approximately 1½" square each. Concentration of sponge micro shrinkage. Remainder clean.
3/8	T6	169504	Two areas on either side of plate approximately 1½" square each had concentration of sponge micro shrinkage. Remainder clean.
3/8	T2	169505	One area on side of plate approximately 2" square had concentration of sponge micro shrinkage. Scattered micro shrinkage in remainder.
3/8	AC	169506	One area on side of plate approximately 2" square had concentration of sponge micro shrinkage. Scattered micro shrinkage in remainder.
3/4	T4	169507	Light micro shrinkage in very small area. Remainder clean.
3/4	T6	169508	Micro shrinkage in approximately 1" square area. Remainder clean.
3/4	T2	169509	Sponge micro shrinkage in 3 areas ranging from 1" to 2" square. Remainder very clean.
3/4	AC	169510	Sponge micro shrinkage on side of plate 2" square. Micro shrinkage in another area approximately 1" square. Remainder very clean.

SUMMARY TABLE OF AVERAGE VALUES *

Temper	Nominal Thickness	Ultimate Tensile Strength (psi)	Yield Strength .2% Offset (psi)	% Elongation in 2"
AC	3/32	24480	16720	2.3
	3/16	23140	15270	2.25
	3/8	23100	13050	2.7
	3/4	24890	13660	4.5
-T2	3/32	22730	19080	1.8
	3/16	28940	18710	2.1
	3/8	23200	14430	3.1
	3/4	24780	13840	3.8
-T4	3/32	26340	17950	3.3
	3/16	25390	15610	2.6
	3/8	30000	13790	4.5
	3/4	29880	15150	5.0
-T6	3/32	28660	20660	1.8
	3/16	31490	20560	1.75
	3/8	32440	16030	3.25
	3/4	32030	17590	3.9

* Values are average of 2 or more specimens.

SUMMARY OF TEST RESULTS, ALL PLATE

THICKNESS, IN "AS CAST" CONDITION

	Specimen Code (1)	Failure Zone(2)	Ult. Ten. Strength(PSI)	Yield Strength .2% Offset(PSI)	% Elongation in 2"
	169498-1	5	26,180	16,620	-
	-2	2	21,300	15,500	1.5
	-3	5	22,450	14,300	-
t = 3/32	-4	3-4	25,600	16,900	2.5
	-5	1	24,750	-	
	-6	4	26,900	19,300	3.0
	169502-1	5	18,700	14,750	-
	-2	5	21,900	16,100	-
t = 3/16	-3	5	24,400	15,600	-
	-4	2	25,200	14,200	2.5
	-5	5	25,500	15,700	2.0
	169506-1	5	22,750	13,250	- (1.5)
	-2	1	22,350	13,050	- (3.0)
t = 3/8	-3	1	23,600	12,050	- (2.5)
	-4	1-2	23,700	13,850	4.0
	169510-1	3-4	25,600	12,800	5.0
	-2	1	25,550	14,500	3.5
t = 3/4	-3	1-2	26,200	13,500	5.0
	-4	5	22,200	13,850	-

(1) Initial series of numbers correspond to x-ray number assigned by the Quality Control Laboratory. The dash number indicates position of specimen in the sheet.

(2) QQ-M-56 requirements

	F_{tu}	F_{ty}	% El. (in 2")
Cast Bar	24000 psi	10000 psi	4.0%
Specimen from Casting	18000	-	1.0%

SUMMARY OF TEST RESULTS, ALL PLATE

THICKNESS, IN -T2 CONDITION (1)

	Specimen Code	Failure Zone(2)	Ult. Ten. Strength(psi)	Yield Strength .2% Offset(psi)	% Elongation in 2"
t = 3/32	169497-1	1	20,400	17,750	-
	-2	3-4	22,800	22,000	1.0
	-3	Improper Test			-
	-4	1	20,700	17,500	2.5
	-5	1	27,000	-	
	-6	No specimen			
t = 3/16	169501-1	2	30,400	18,300	3.0
	-2	2-3	28,100	19,250	2.0
	-3	1-2	28,350	18,780	2.0
	-4	4	27,550	18,600	1.5
	-5	4-5	30,300	18,600	2.0
t = 3/8	169505-1	2-3	19,400	14,200	1.2
	-2	5	23,000	14,700	- (1.2)
	-3	5	25,200	14,550	- (2.0)
	-4	3-4	25,200	14,250	4.0
t = 3/4	169509-1	5	24,000	12,700	-
	-2	2-3	26,000	16,150	4.0
	-3	1	25,800	13,100	-
	-4	4-5	23,300	13,400	3.5

(1) -T2 is also noted "ACS" - As cast and stabilized.

(2) QQ-M-56 requirements

	Ftu	Fty	% El. (in 2")
Cast Bar (separately)	24000 psi	11000 psi	2.0%
Specimen from Casting	18000	-	0.5

SUMMARY OF TEST RESULTS, ALL PLATE

THICKNESSES, IN -T4 CONDITION

	Specimen Code	Failure Zone	Ult. Ten. Strength(psi)	Yield Strength .2% Offset(psi)	% Elongation in 2"
	169495-1	Failed in Grip			
	-2	5	26,450	17.500	3.0
t = 3/32	-3	4	25,760	18,100	3.5
	-4	>5	26,800	19,100	-
	-5	No Specimen			
	-6	No Specimen			
	169499-1	>5	25,000	15,000	-
	-2	4	26,400	14,600	3.0
t = 3/16	-3	3	24,350	17,050	2.5
	-4	1	27,250	15,150	3.0
	-5	1	23,950	16,250	2.0
	169503-1	2	28,200	14,000	4.5
	-2	>5	30,800	13,500	- (4.5)
t = 3/8	-3	>5	32,000	14,200	- (4.5)
	-4	>5	29,000	13,450	- (4.5)
	169507-1	1	27,900	14,900	4.0
	-2	Failed in Grip			
t = 3/4	-3	Failed in Grip			
	-4	2	31,850	15,400	6.0

QQ-M-56 requirements

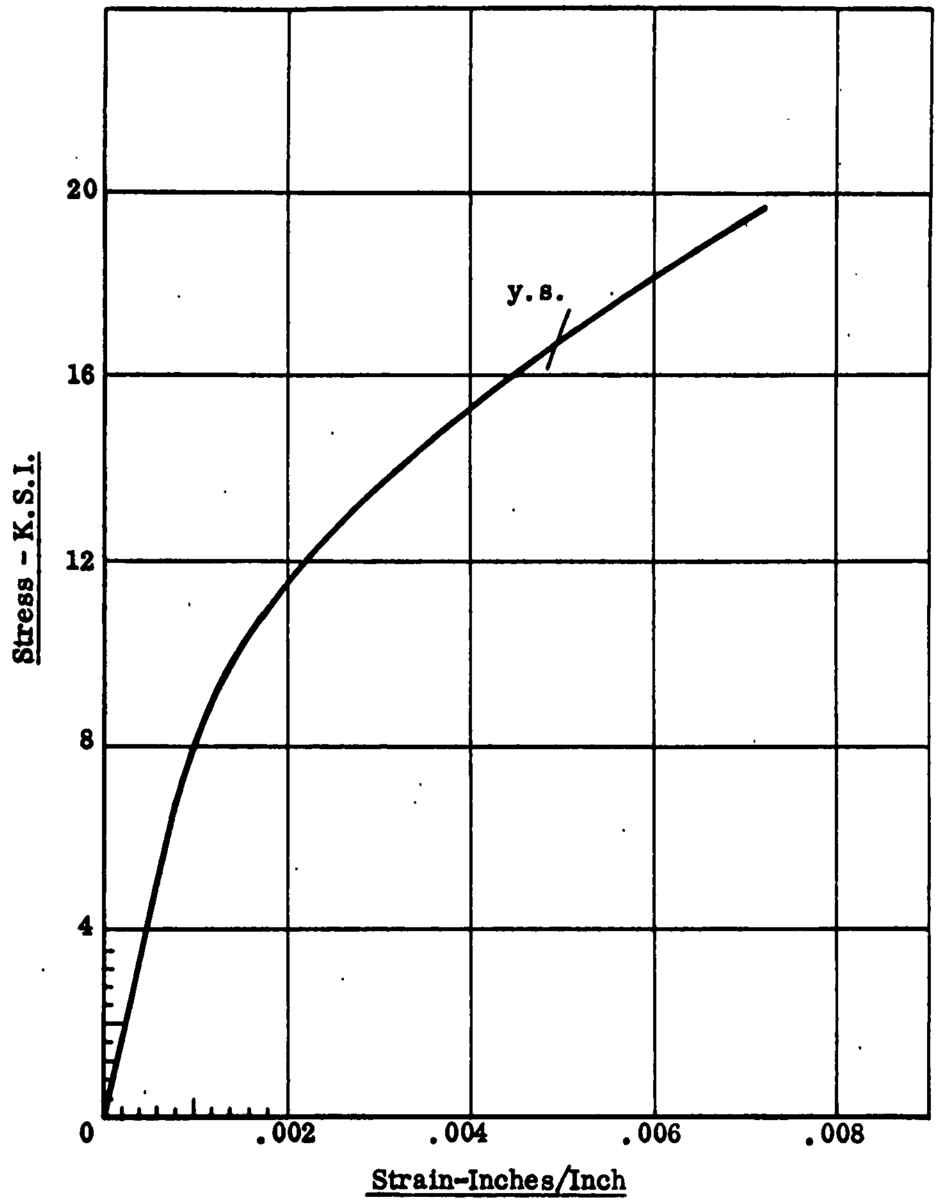
	Ftu	Fty	% El. (in 2")
Separately Cast Bar	34,000psi	10,000psi	7.0%
Specimen from Casting	25,500	-	1.75

SUMMARY OF TEST RESULTS, ALL PLATE THICKNESSES, IN -T6 CONDITION

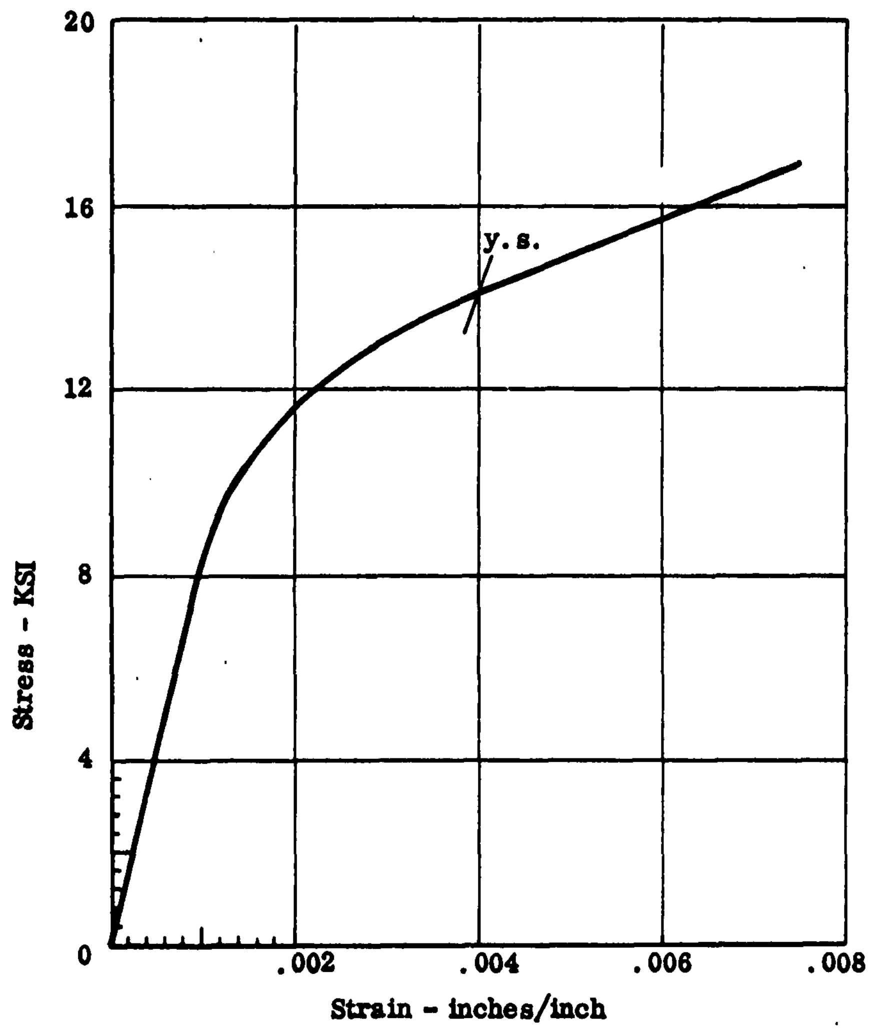
	Specimen Code	Failure Zone	Ult. Ten. Strength(psi)	Yield Strength .2% Offset(psi)	% Elongation in 2"
t = 3/32	169496-1	1	33,200	21,900	2.0
	-2	3	28,200	24,700	2.0
	-3	>1	25,800	19,450	-
	-4	>1	26,240	17,160	-
	-5	5	29,850	20,100	1.5
	-6	No Test			
t = 3/16	169500-1	1	27,300	21,000	1.5
	-2	>5	32,650	20,550	-
	-3	>5	30,900	19,900	-
	-4	>5	33,150	21,000	-
	-5	2-3	33,450	20,350	2.0
t = 3/8	169504-1	2	29,050	17,500	2.5
	-2	4-5	33,450	16,550	4.5
	-3	5	33,400	18,100	-(3.0)
	-4	1	33,850	17,950	3.0
t = 3/4	169508-1	3-4	29,100	18,900	2.5
	-2	1-2	31,900	14,850	5.0
	-3	2	33,000	18,600	4.5
	-4	3-4	32,100	17,800	3.5

QQ-M-56 requirements

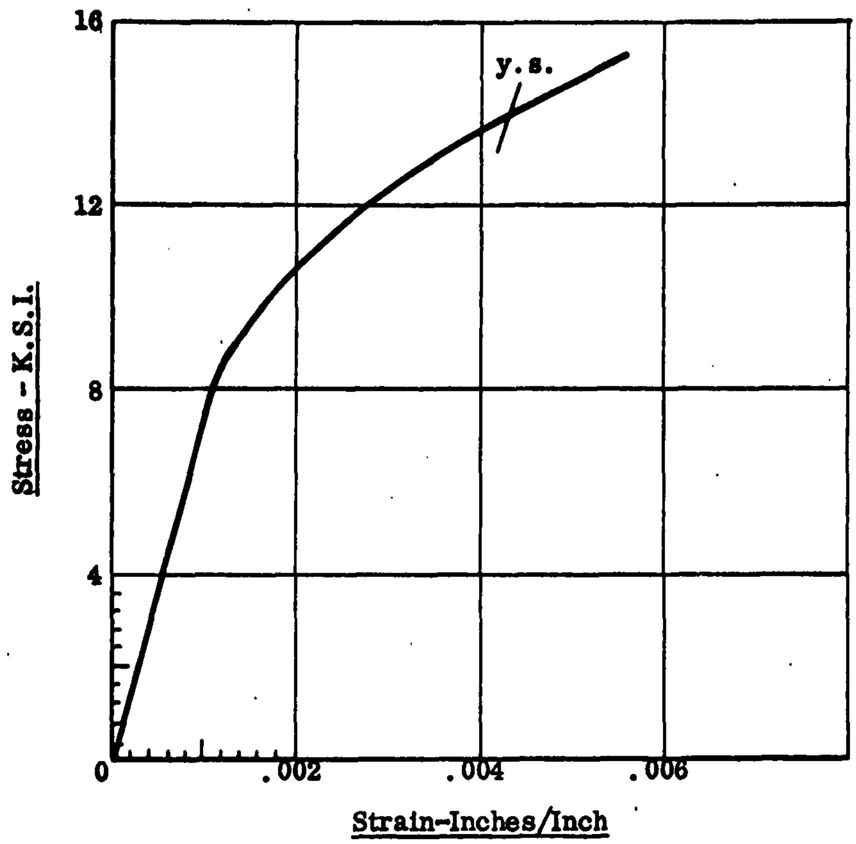
	F_{tu}	F_{ty}	% El. (in 2")
Separately Cast Bar	34000 psi	16000 psi	3.0%
Specimen from Casting	25500	-	0.75



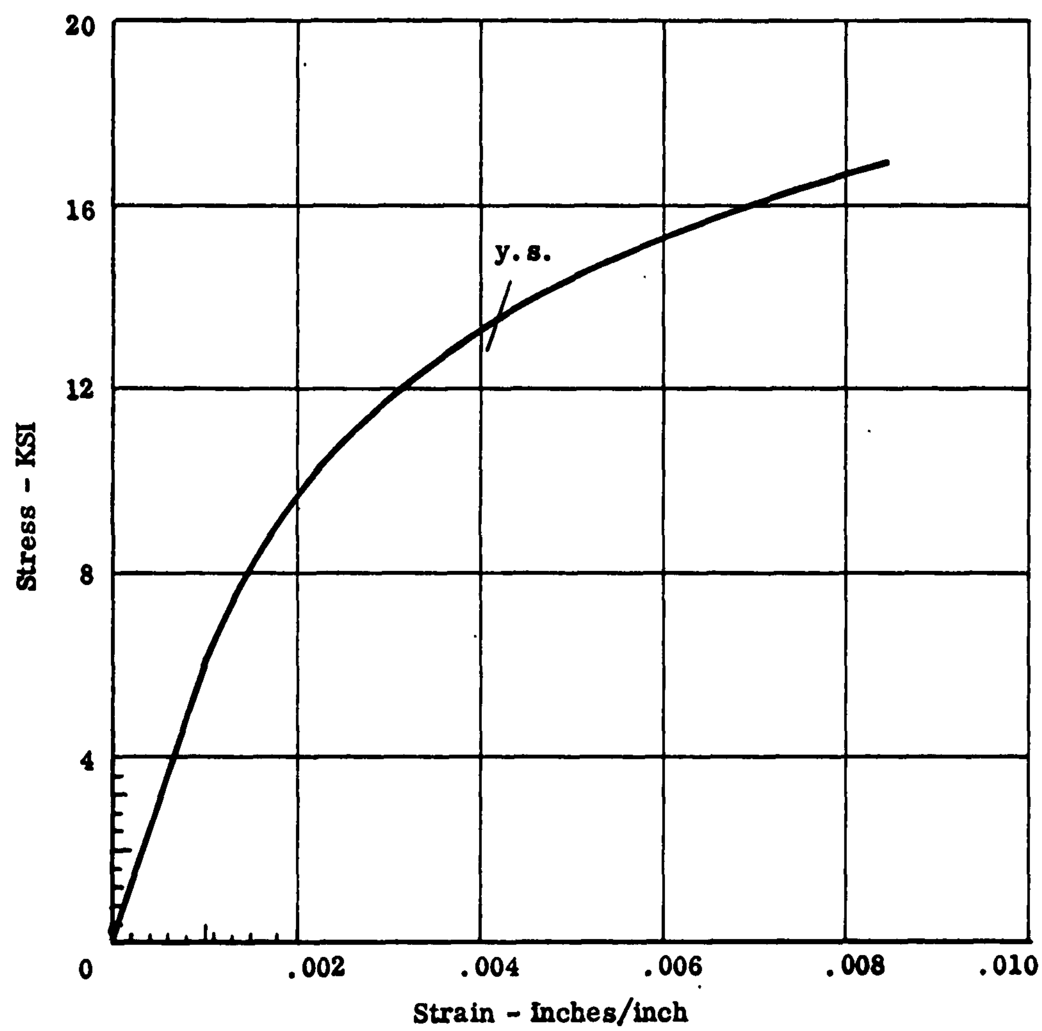
Typical Stress-Strain Curve for
Nominal 3/32 Inch "AC" Plate
169498-4



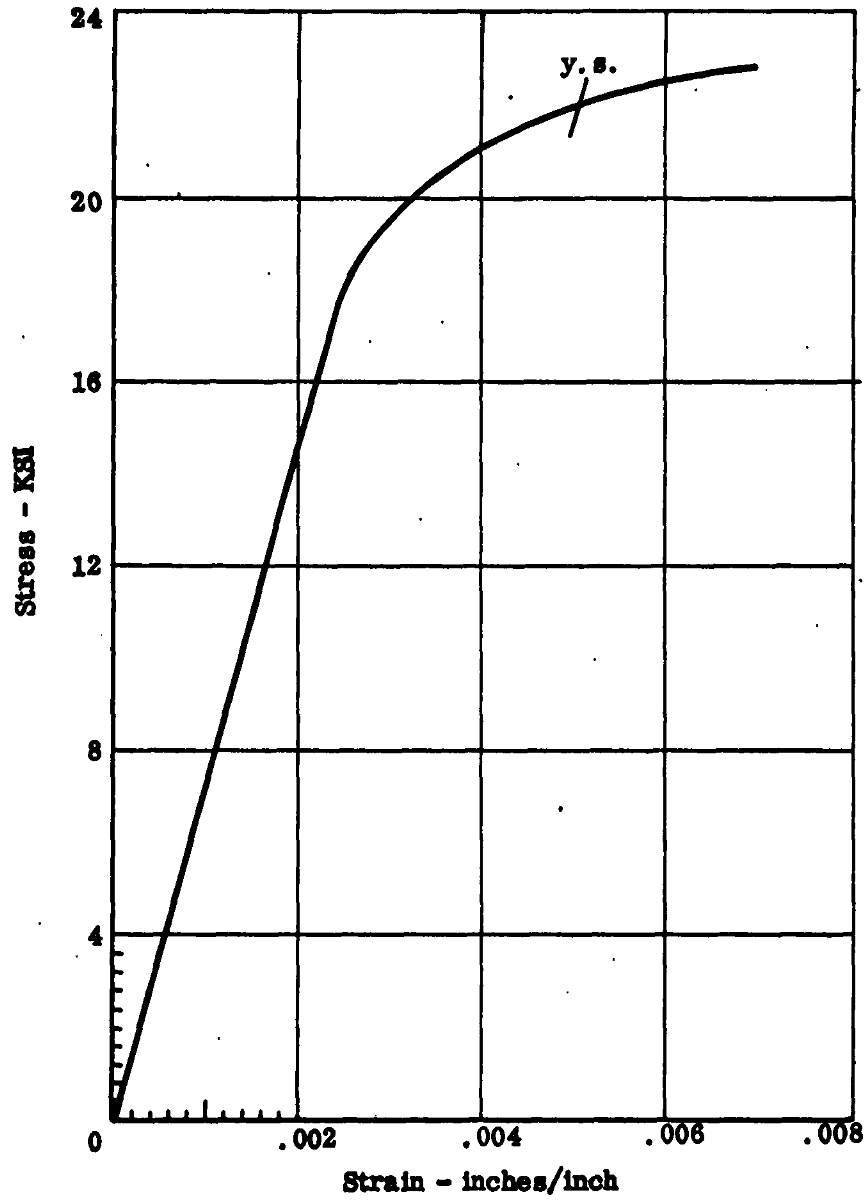
Typical Stress-Strain Curve for
Nominal 3/16 Inch "AC" Plate
169502-4



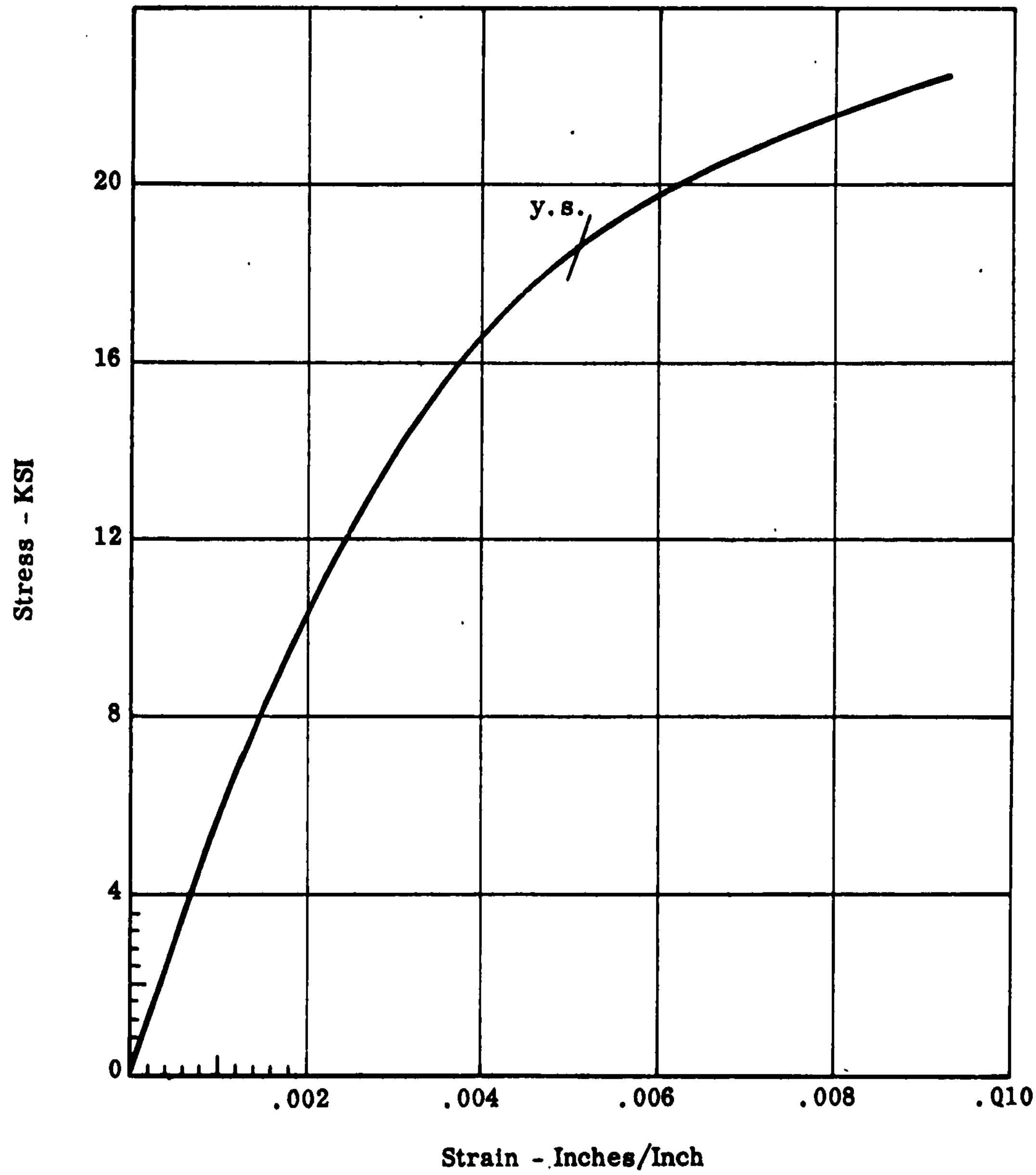
Typical Stress - Strain Curve For
Nominal 3/8 Inch "AC" Plate
169506-4



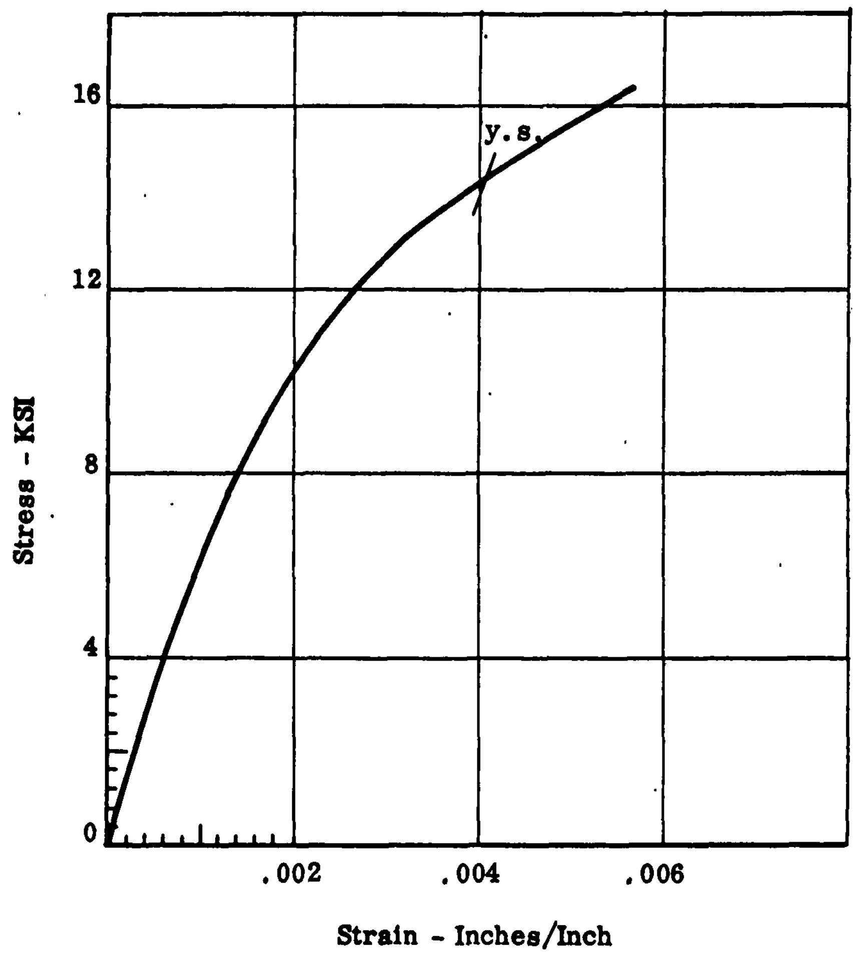
Typical Stress-Strain Curve for
Nominal 3/4 Inch "AC" Plate
169510-3



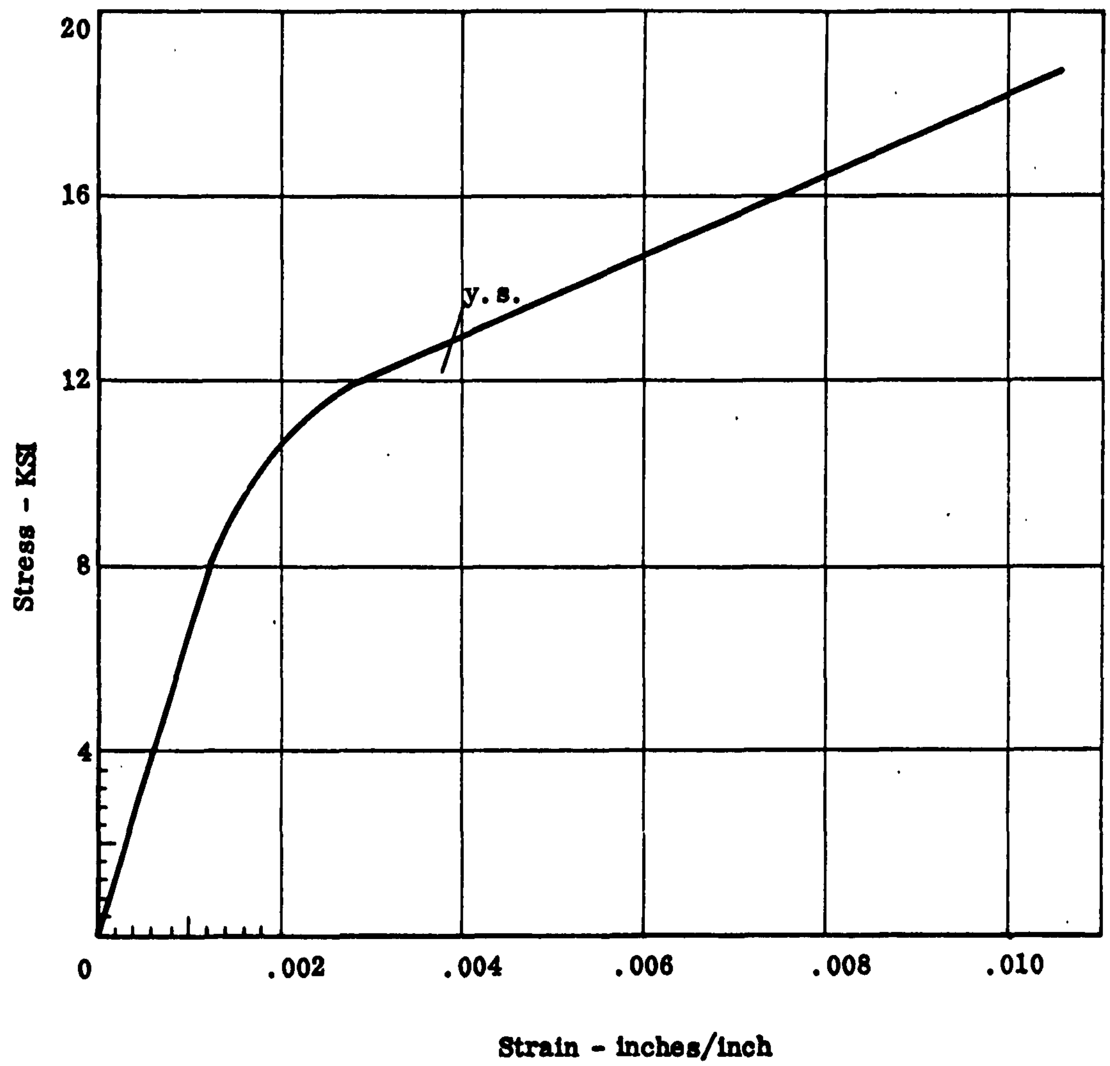
Typical Stress-Strain Curve for
Nominal 3/32 Inch -T2 Plate
169497-2



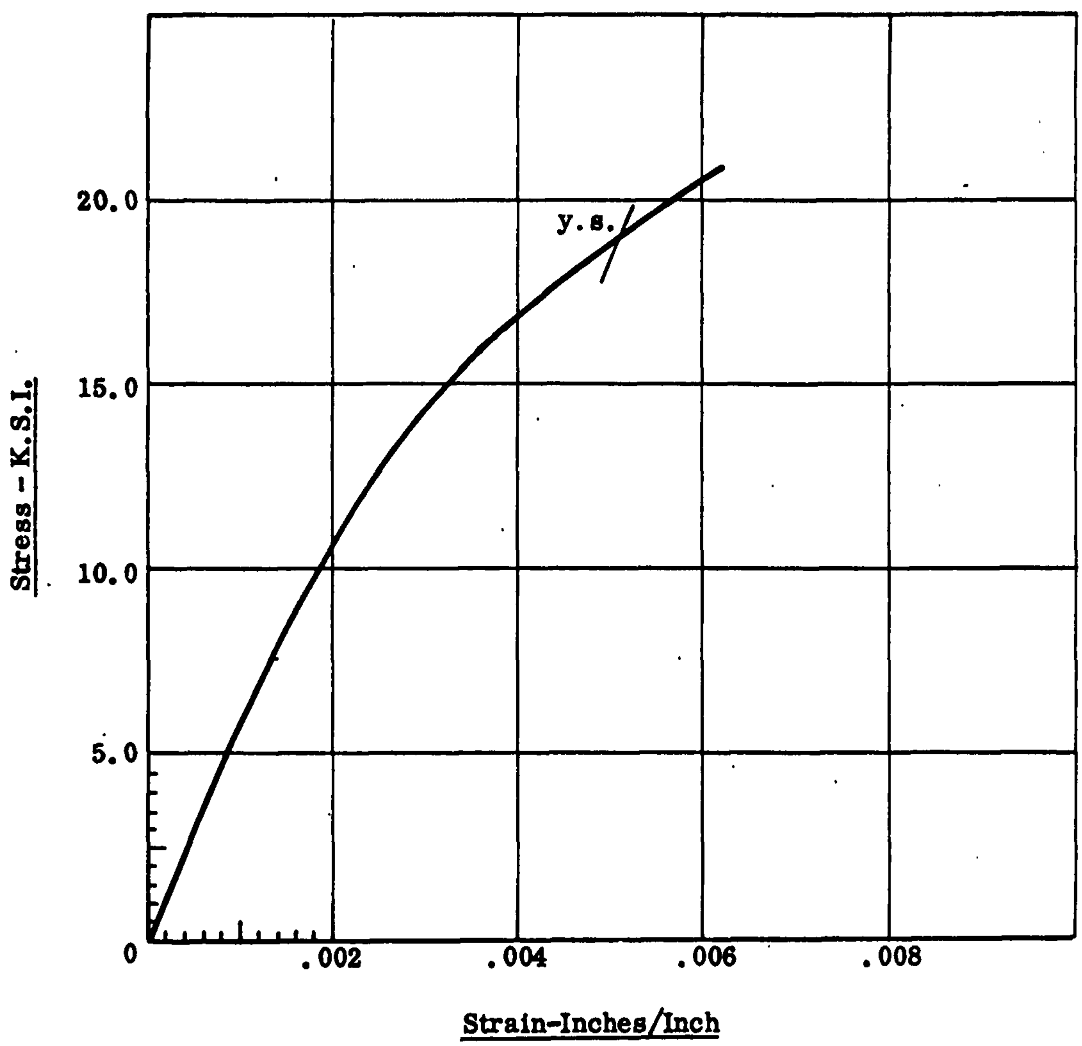
Typical Stress - Strain Curve for
Nominal 3/16" - T2 Plate
169501-4



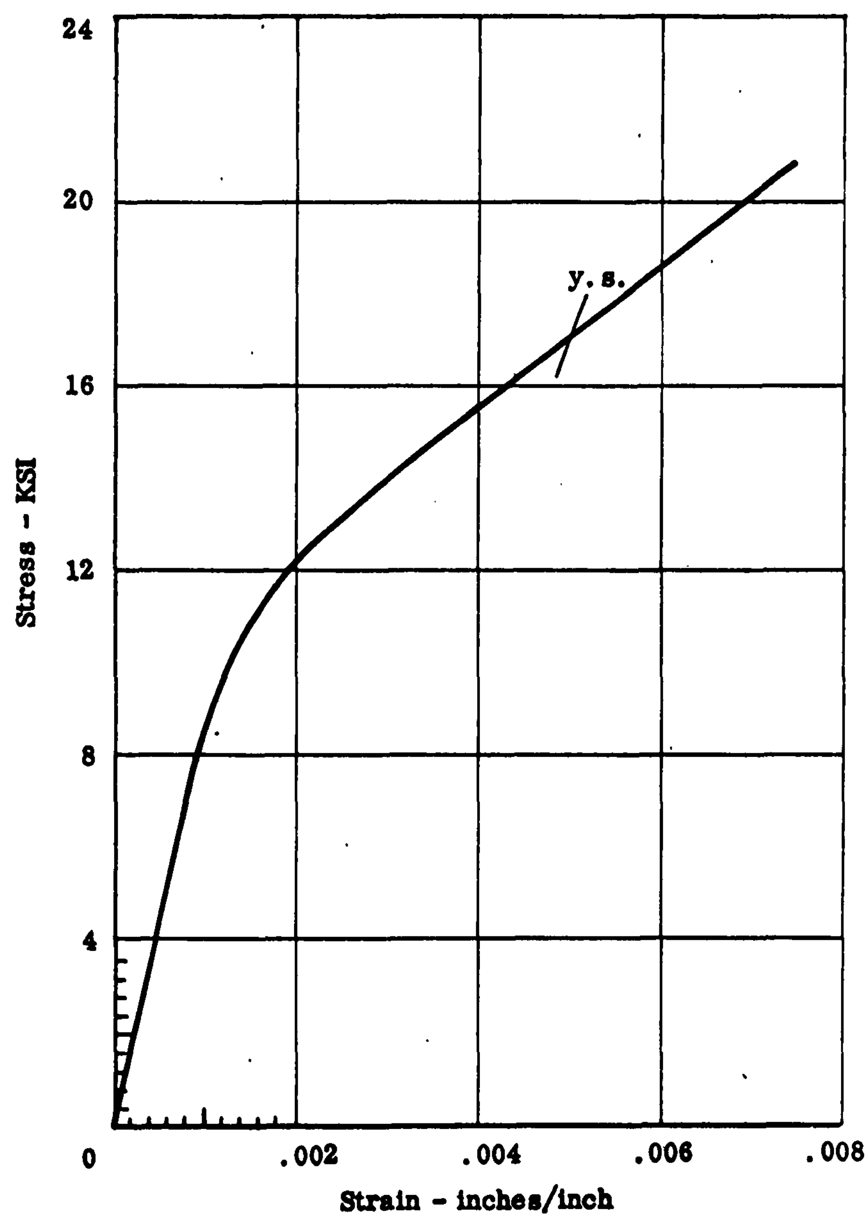
Typical Stress - Strain Curve for
Nominal 3/8" - T2 Plate
169505-4



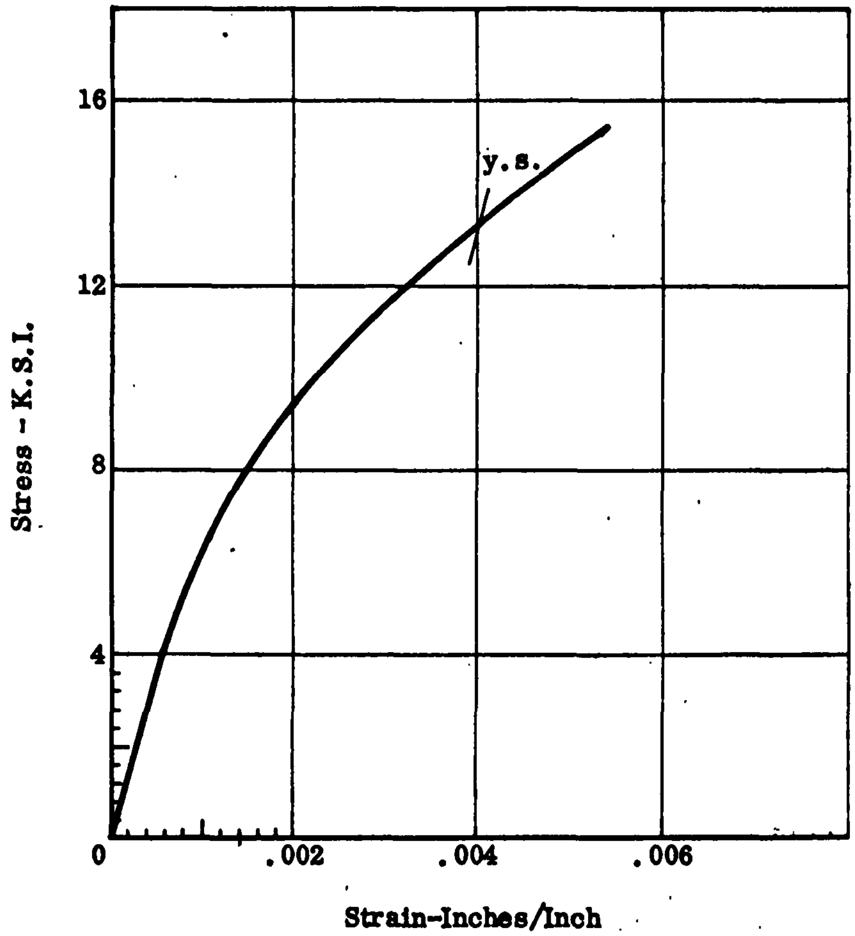
Typical Stress-Strain Curve for
Nominal 3/4 Inch -T2 Plate
169509-3



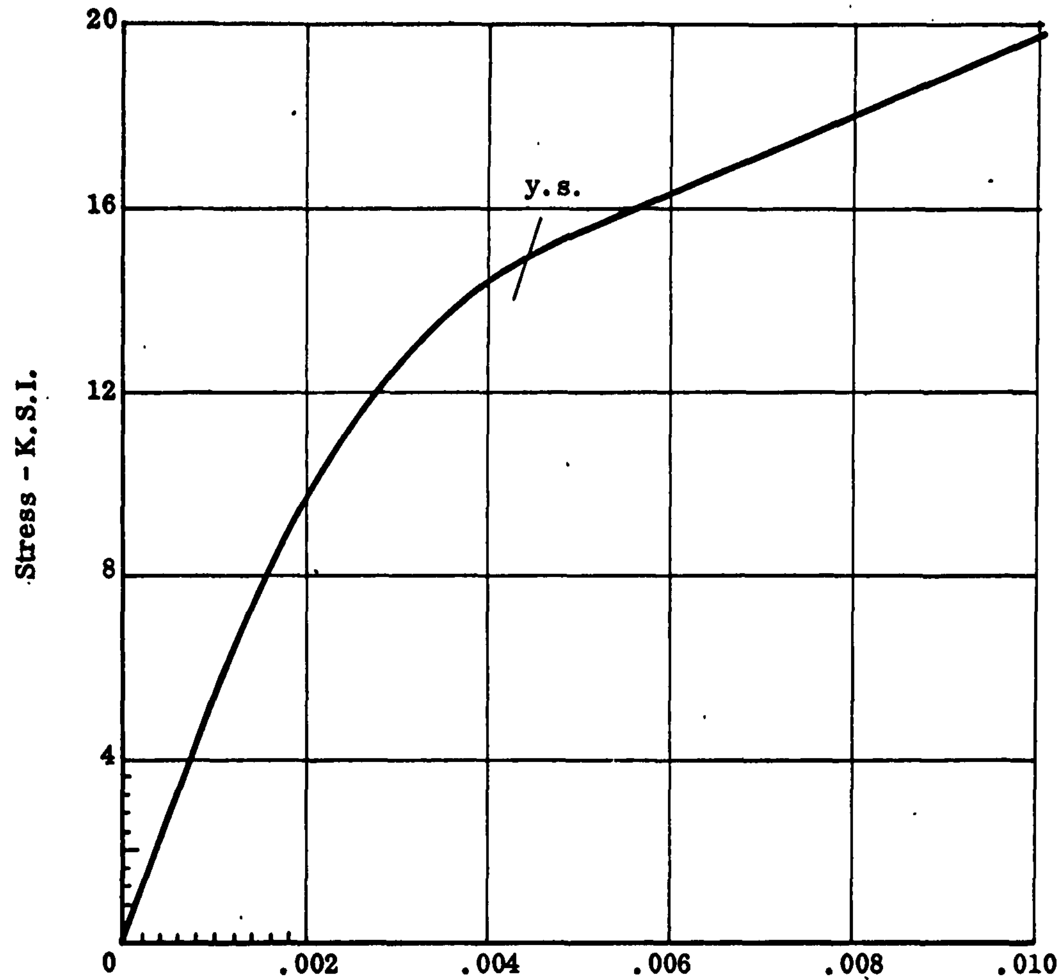
Typical Stress - Strain Curve for
Nominal 3/32 Inch T4 Plate
169495-4



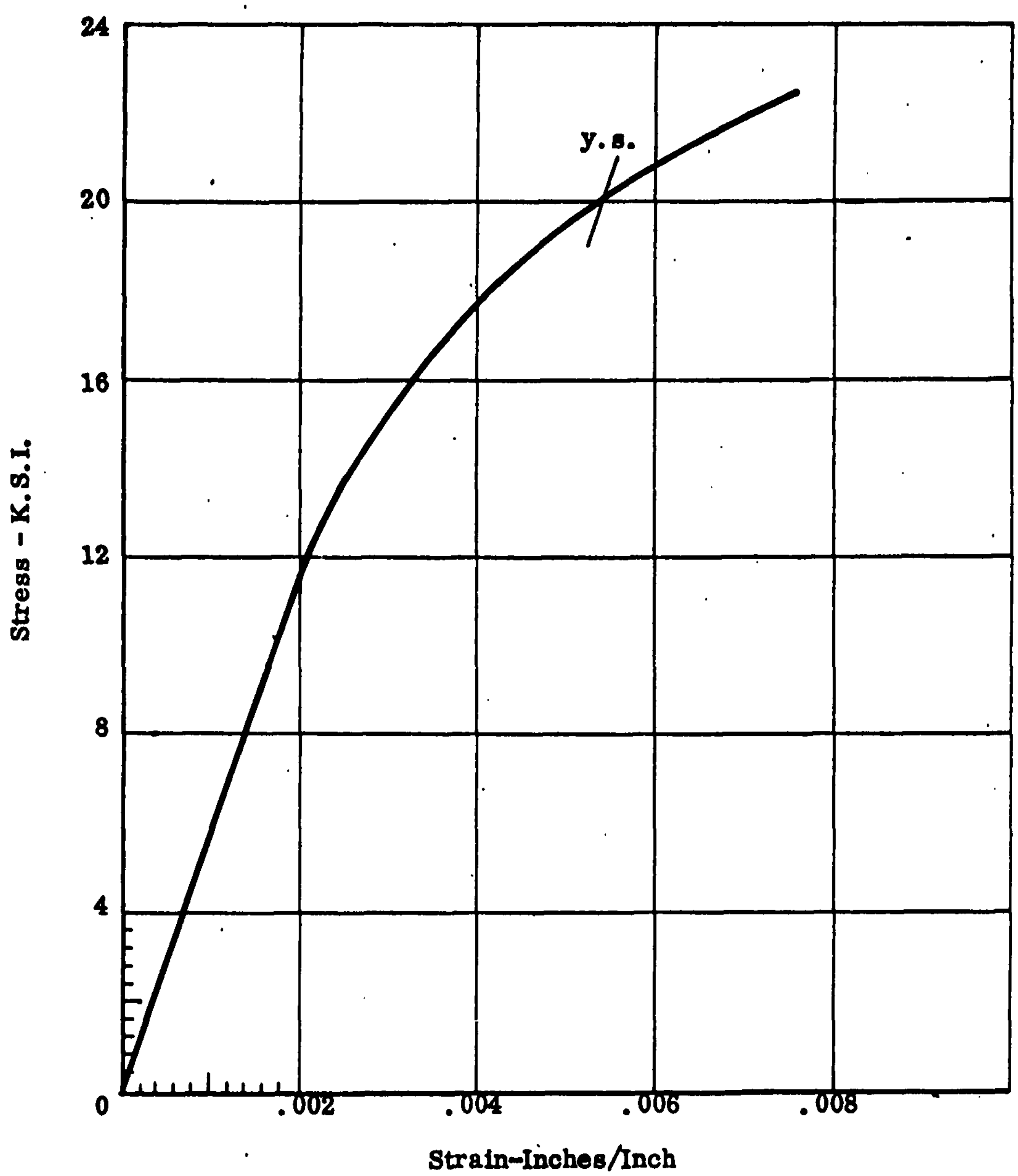
Typical Stress-Strain Curve for
Nominal 3/16 Inch T4 Plate
169499-3



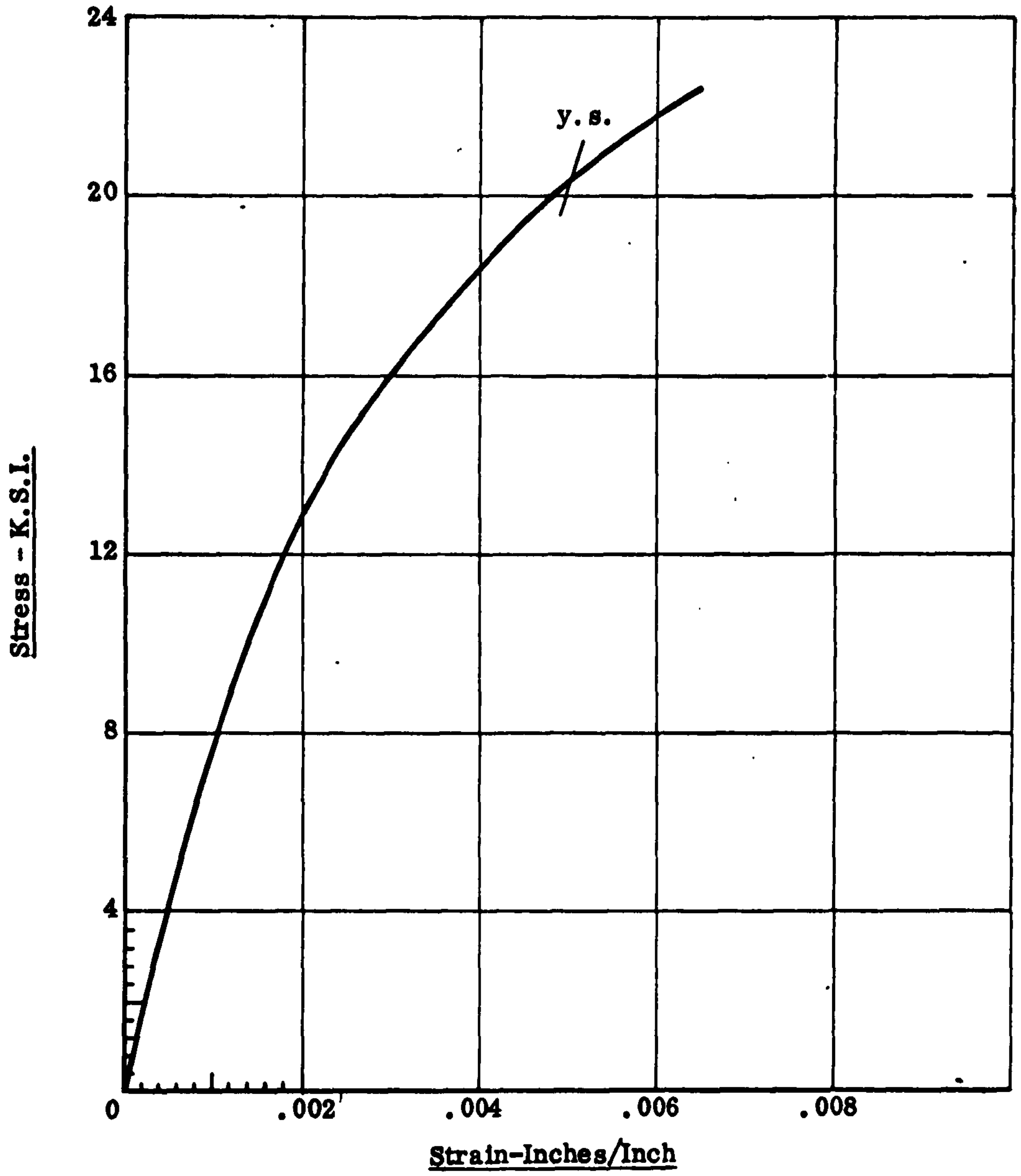
Typical Stress-Strain Curve for
Nominal 3/8 Inch T4 Plate
169503-2



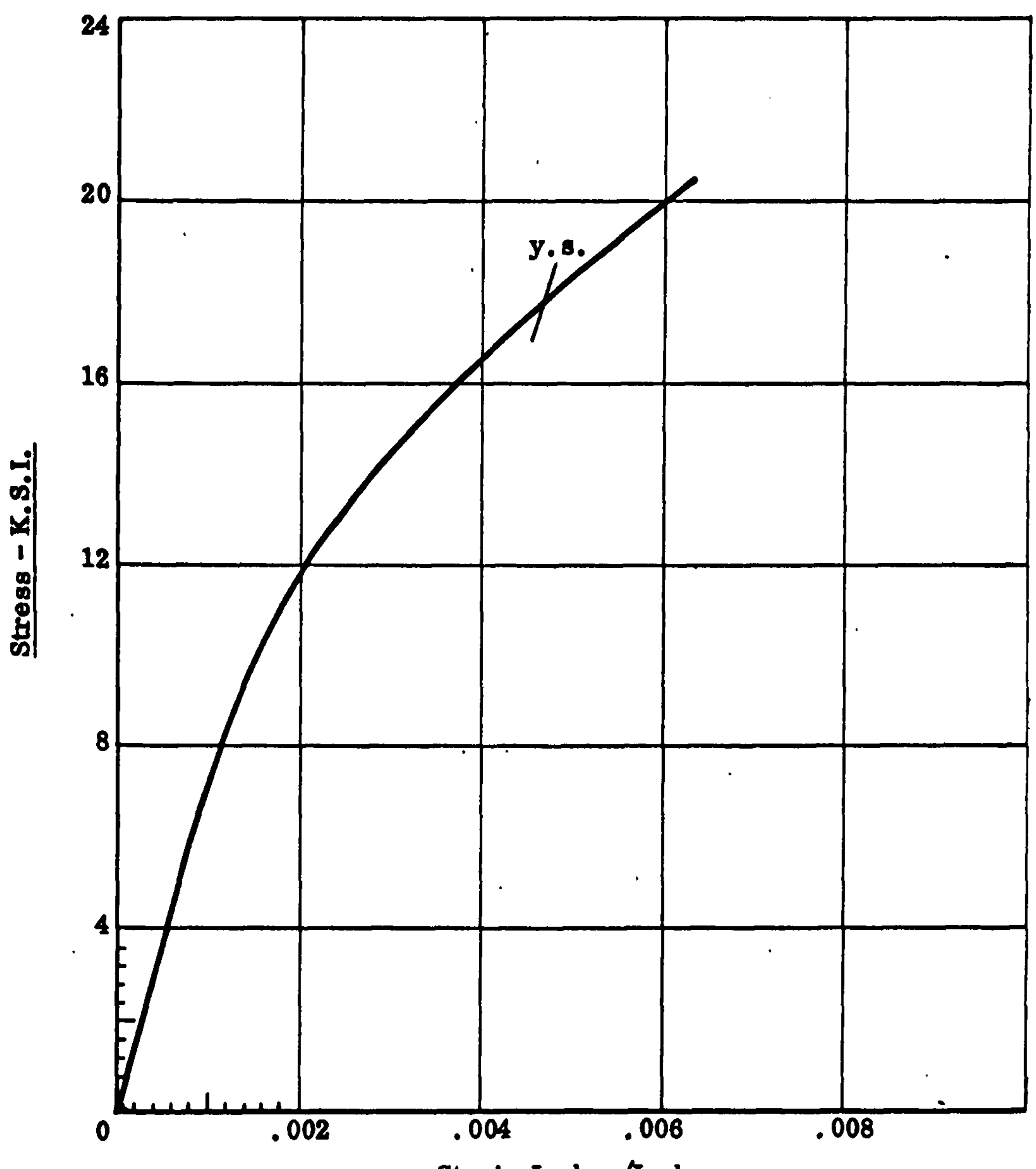
Typical Stress-Strain Curve for
Nominal 3/4 Inch T4 Plate
169507-1



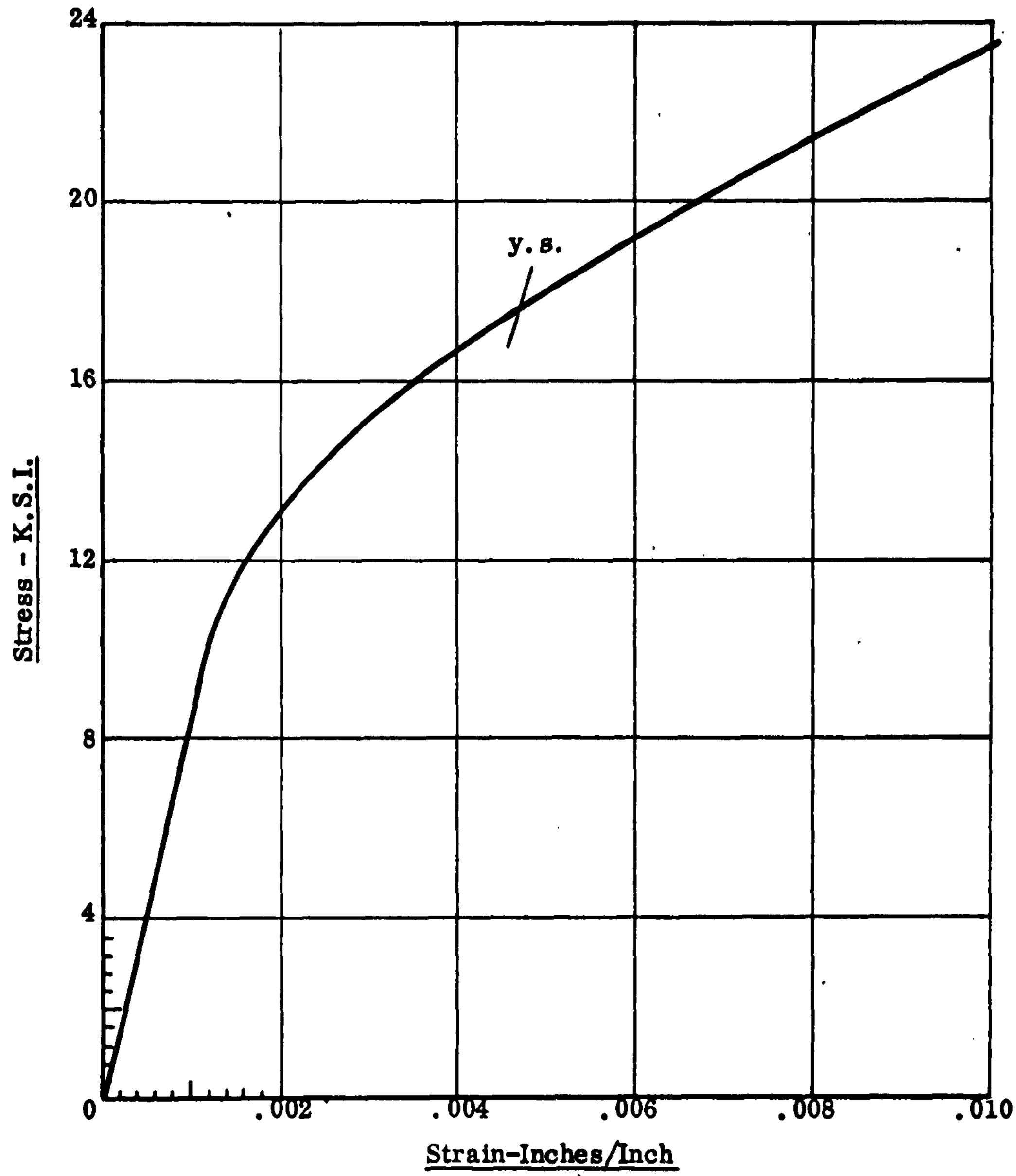
Typical Stress - Strain Curve for
Nominal 3/32 Inch T6 Plate
169496-5



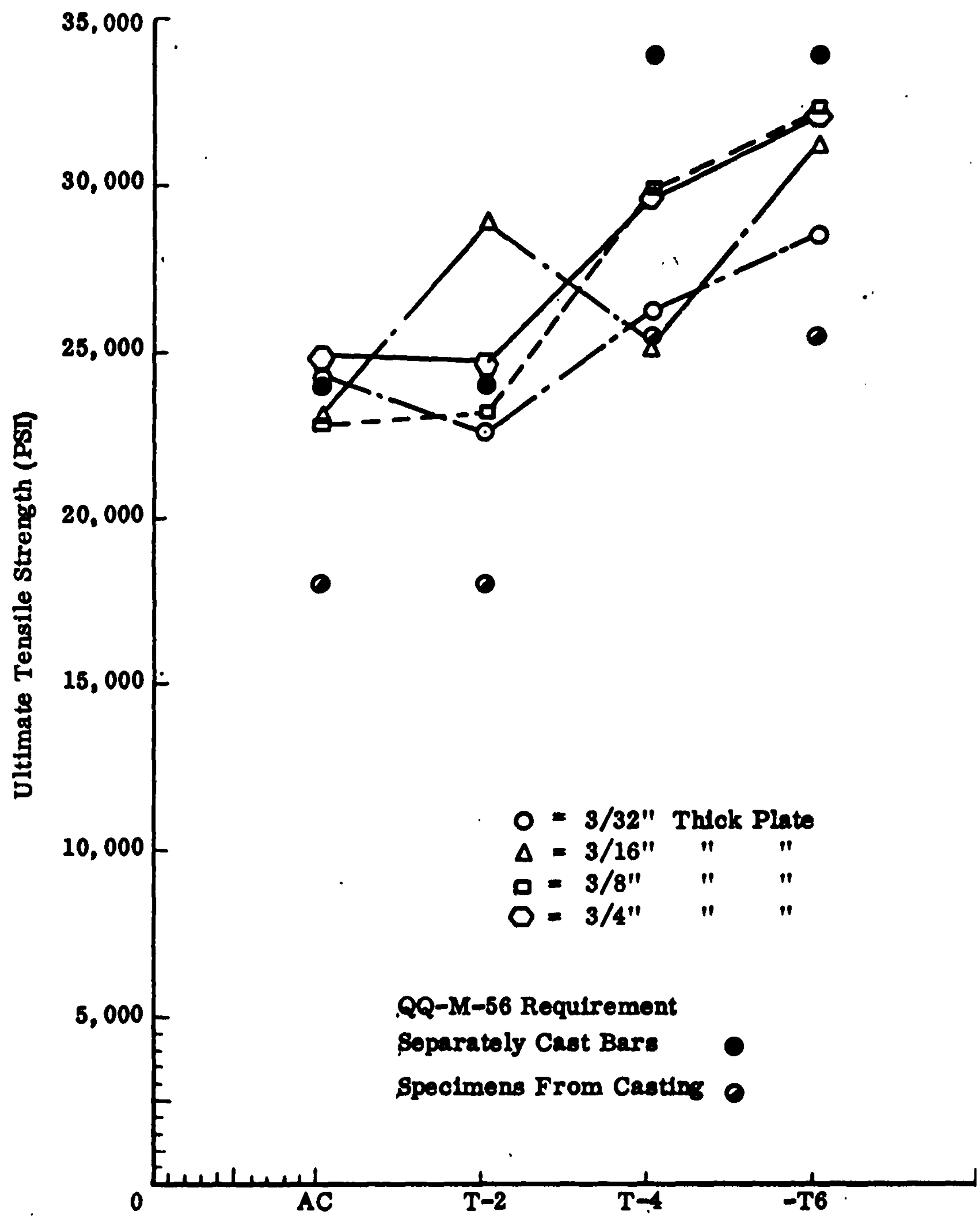
Typical Stress - Strain Curve for
Nominal 3/16 Inch T6 Plate
169500-5



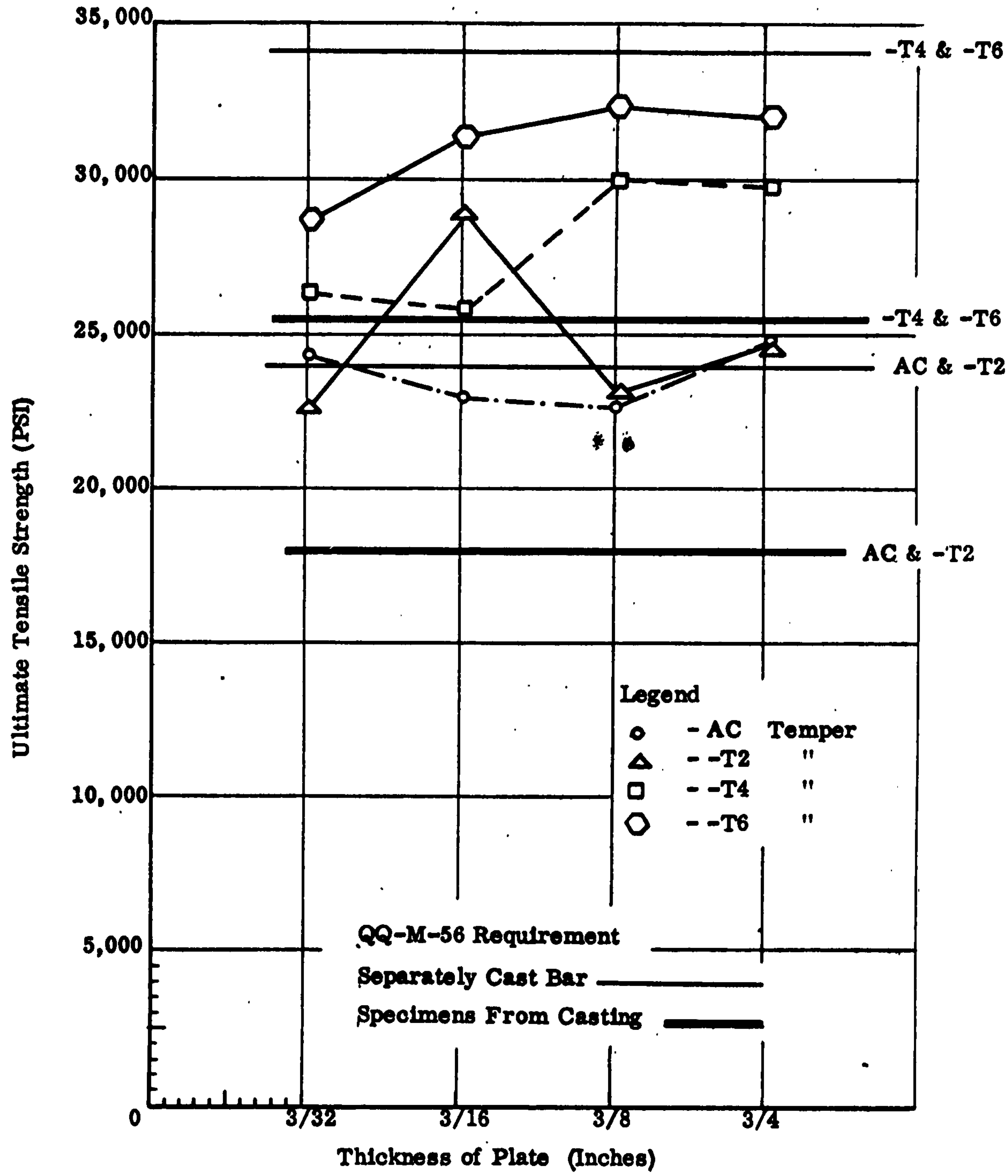
Typical Stress - Strain Curve for
Nominal 3/8 Inch T6 Plate
169504-4



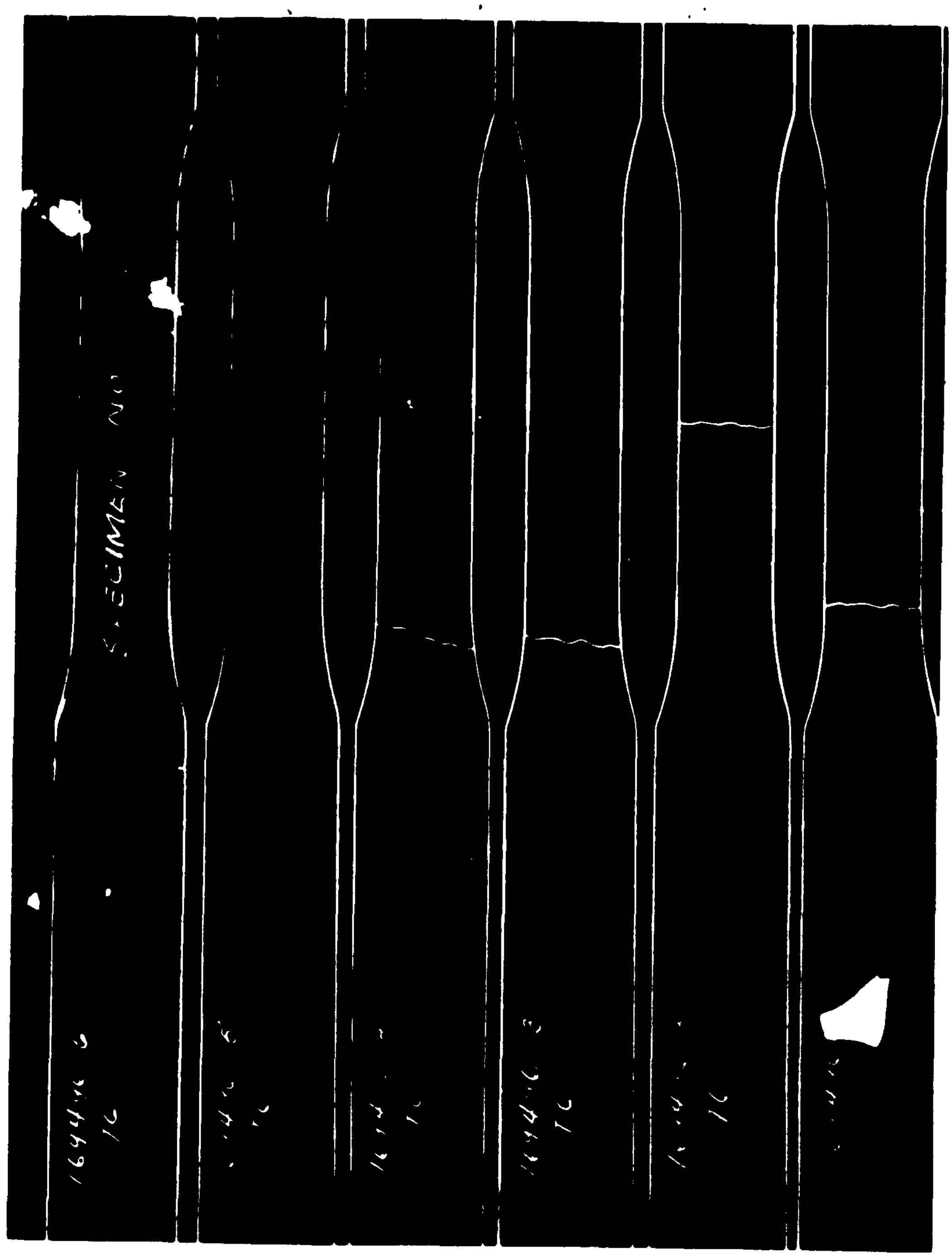
Typical Stress - Strain Curve for
Nominal 3/4 Inch T6 Plate
169508-4

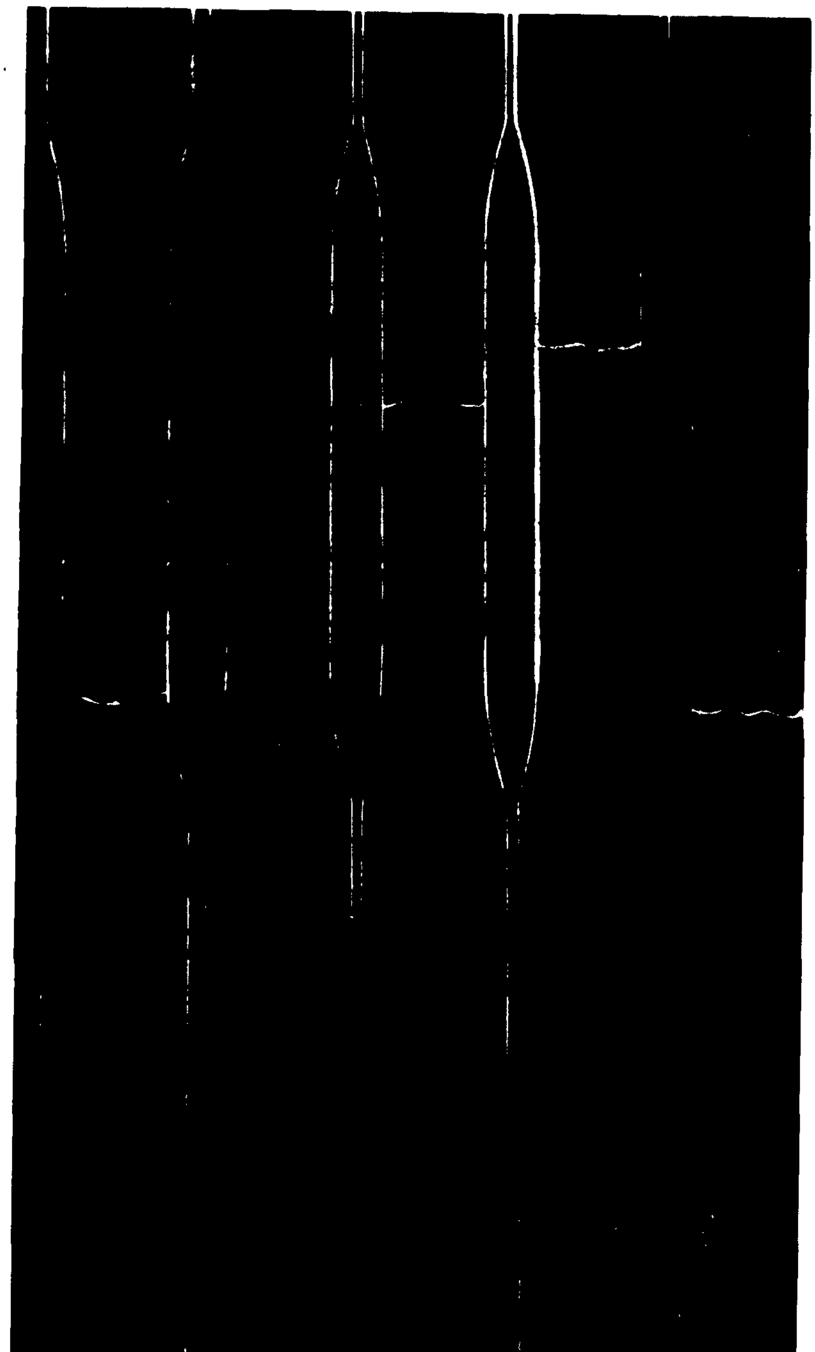


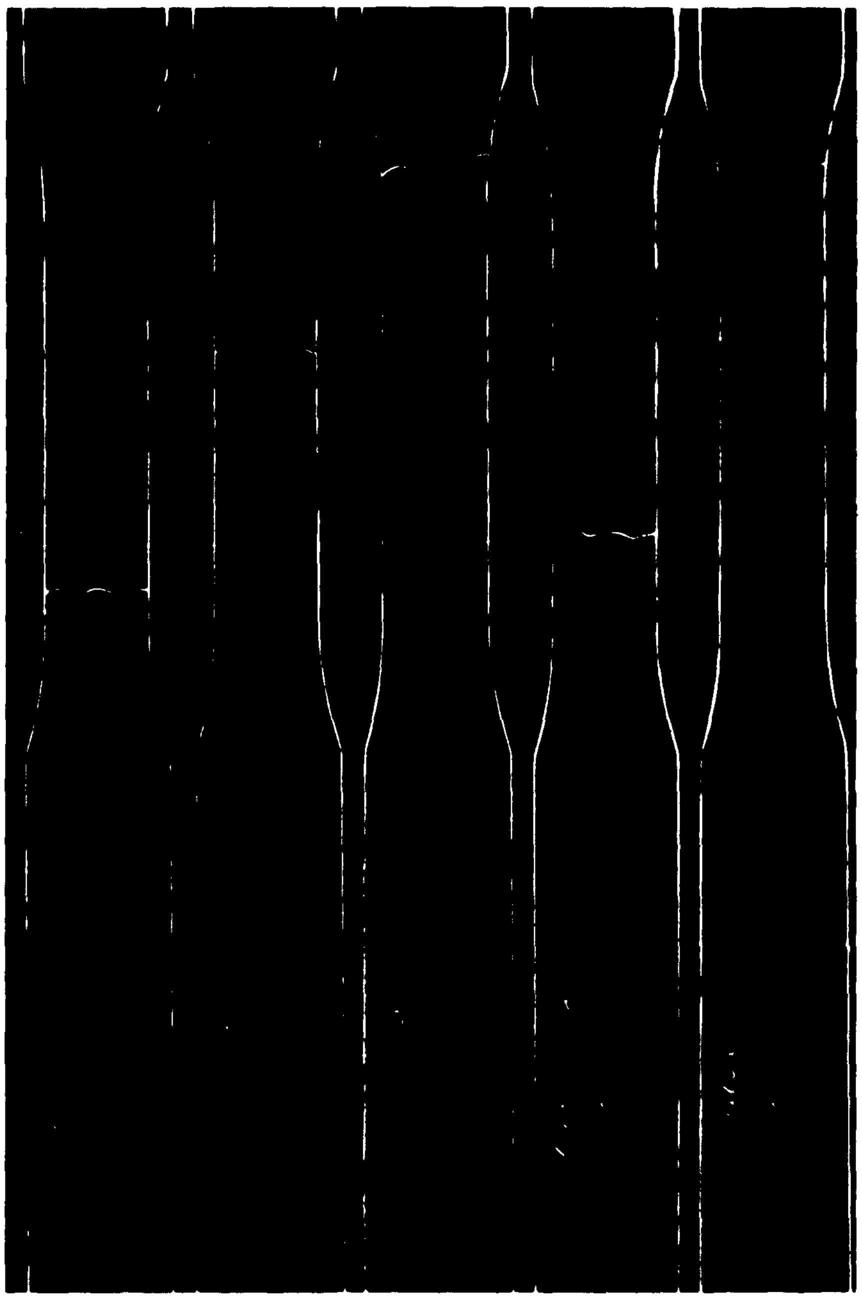
Ultimate Tensile Strength
vs. Temper for Various
Plate Thicknesses

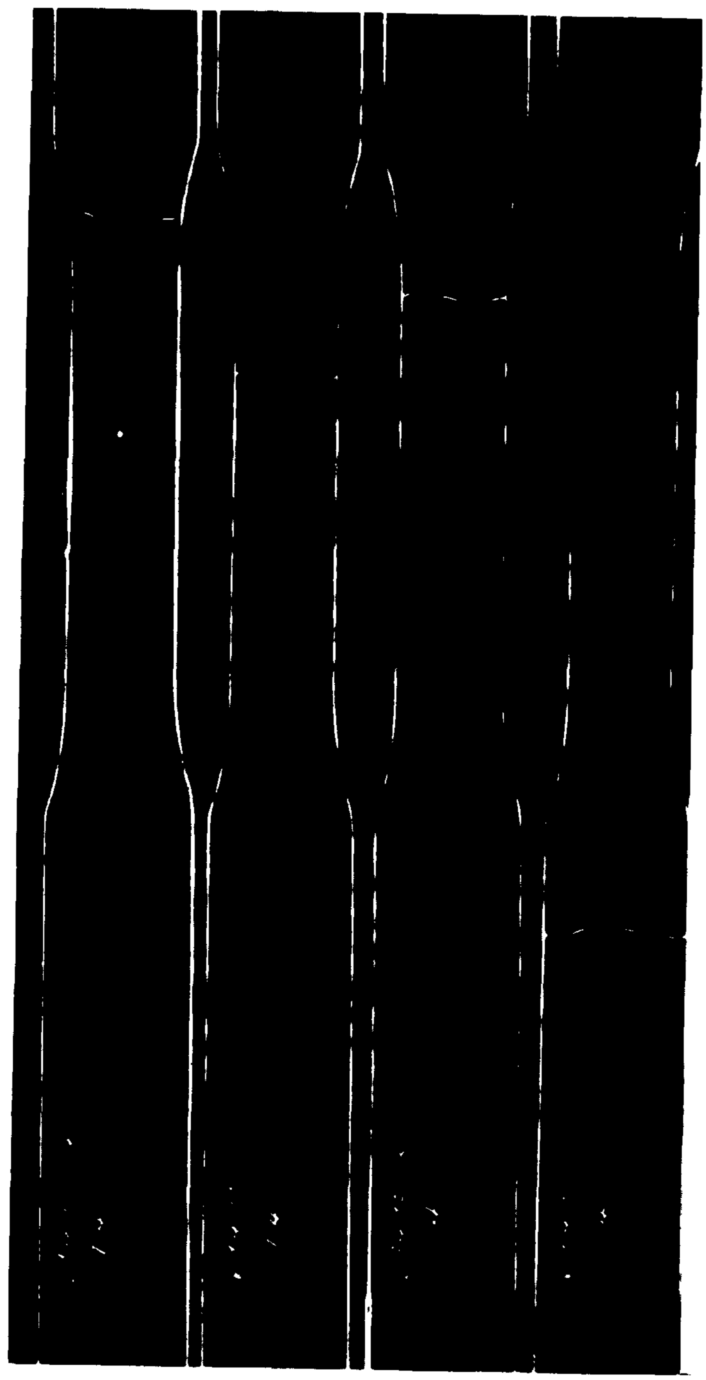


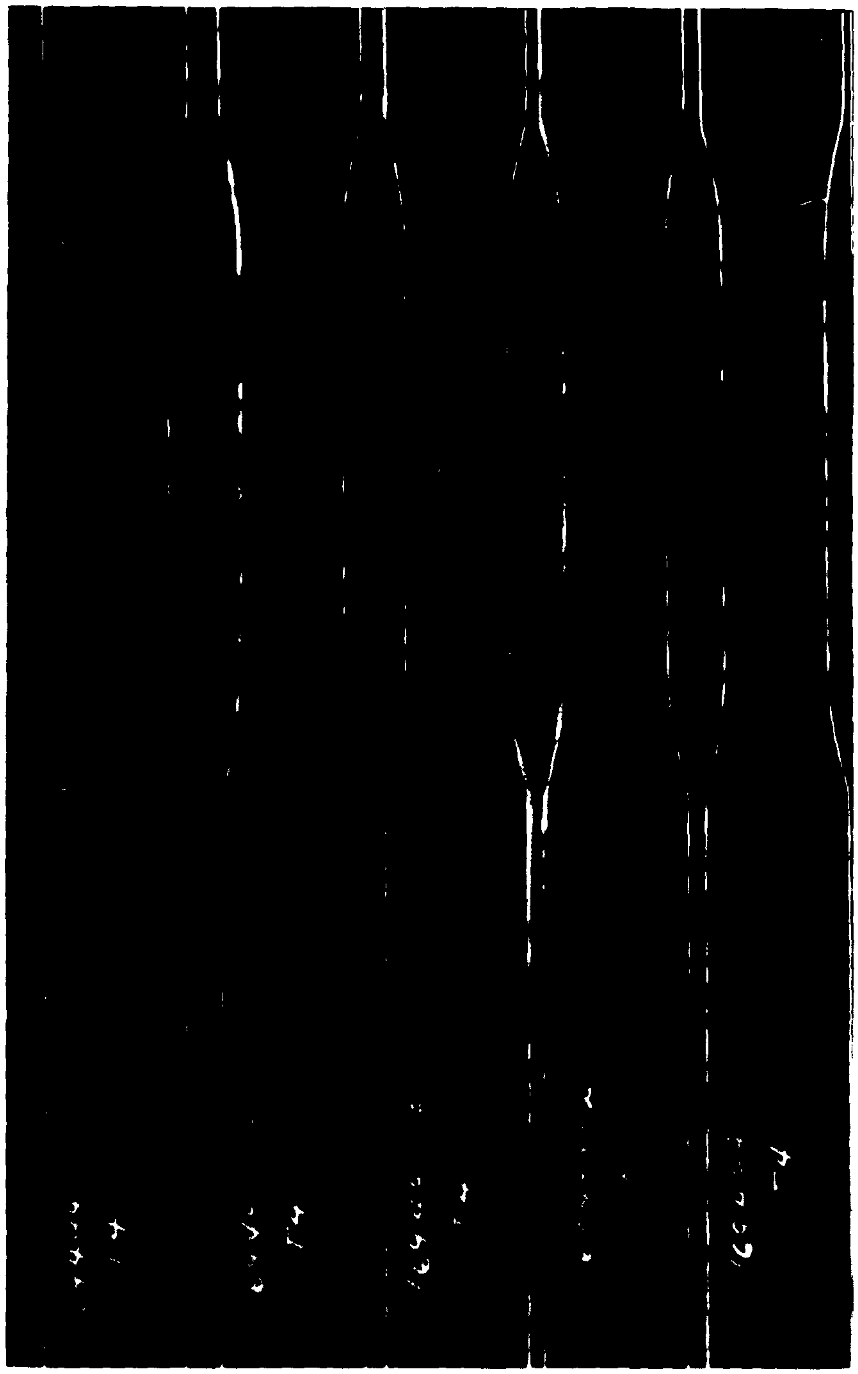
Ultimate Tensile Strength vs
Thickness of Plate for
Various Tempers

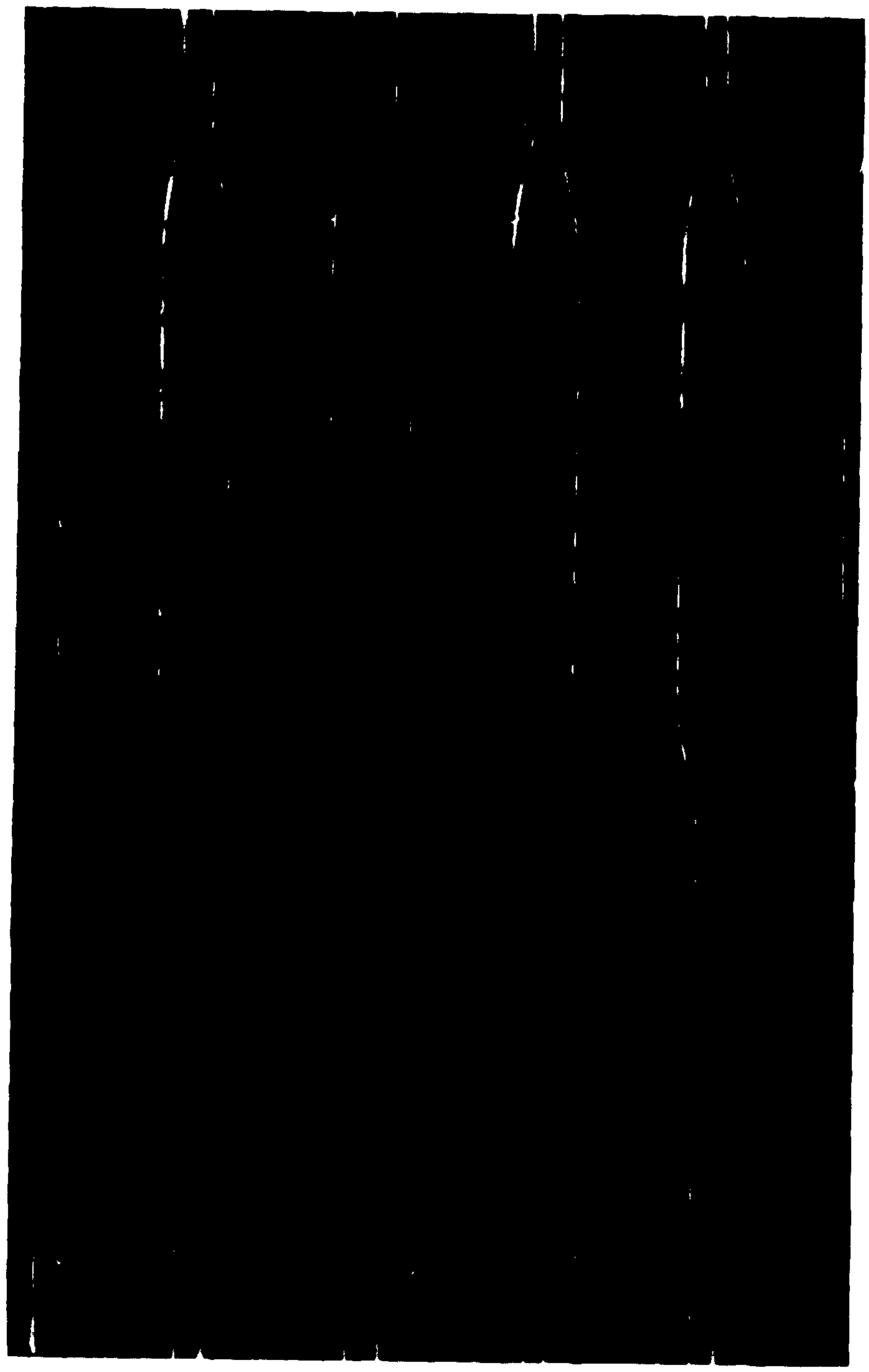


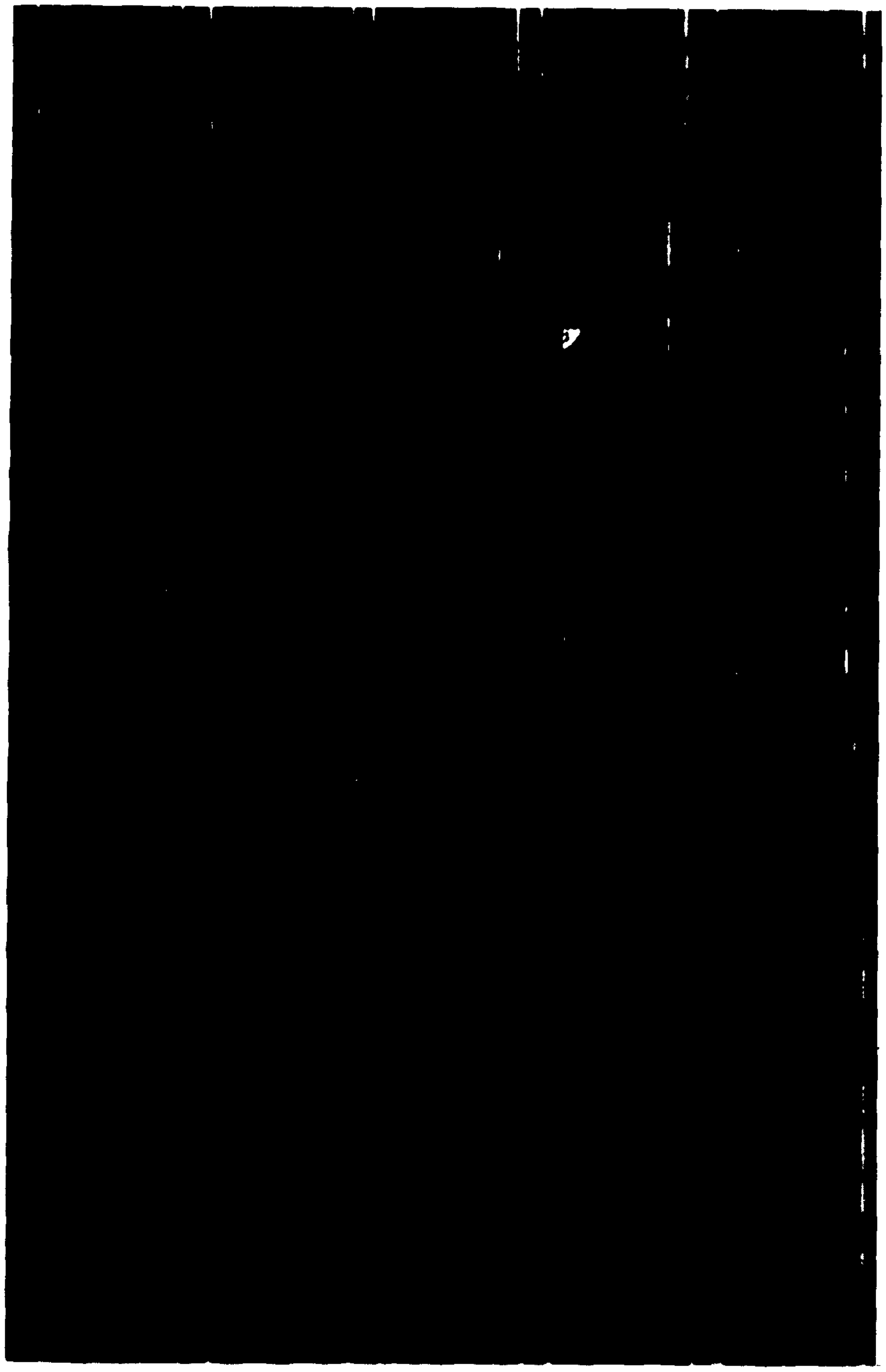


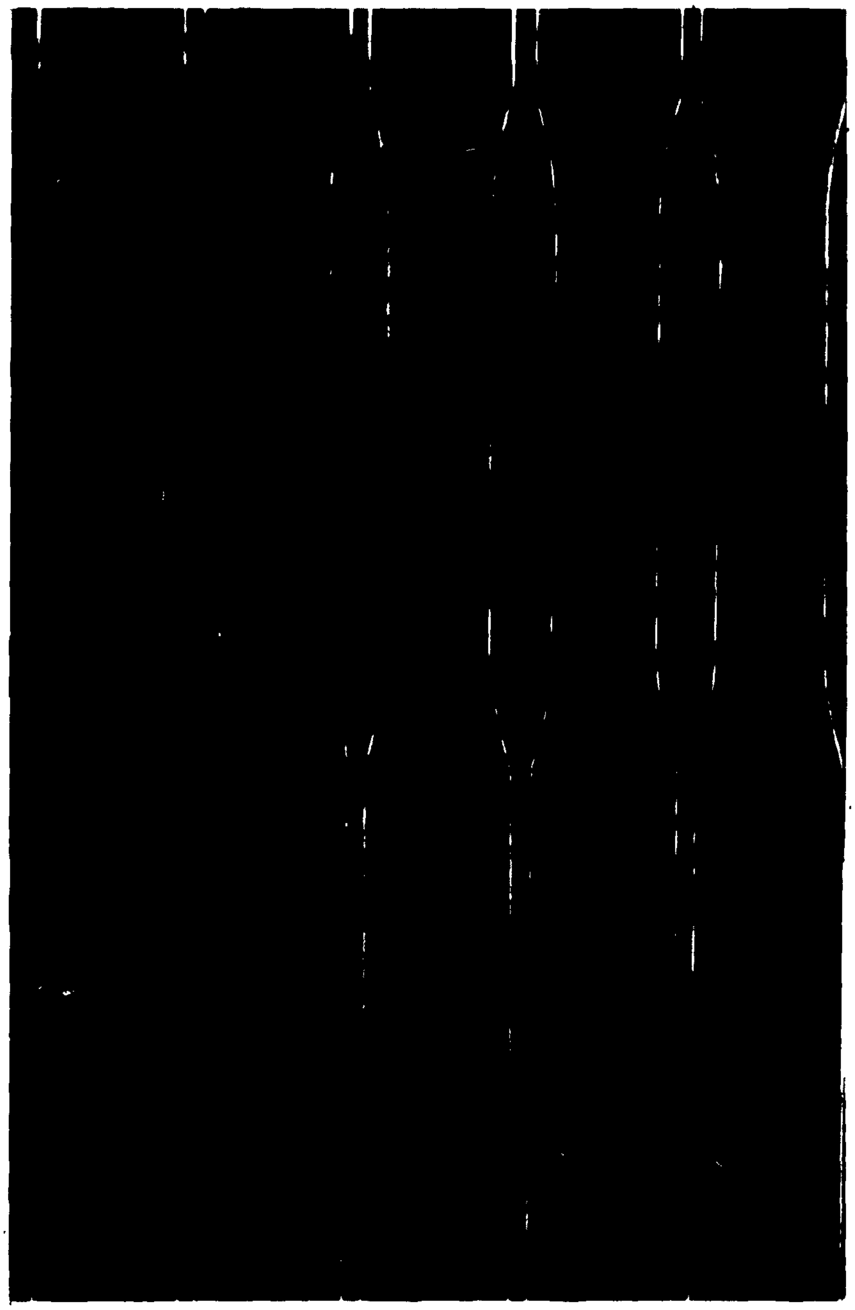


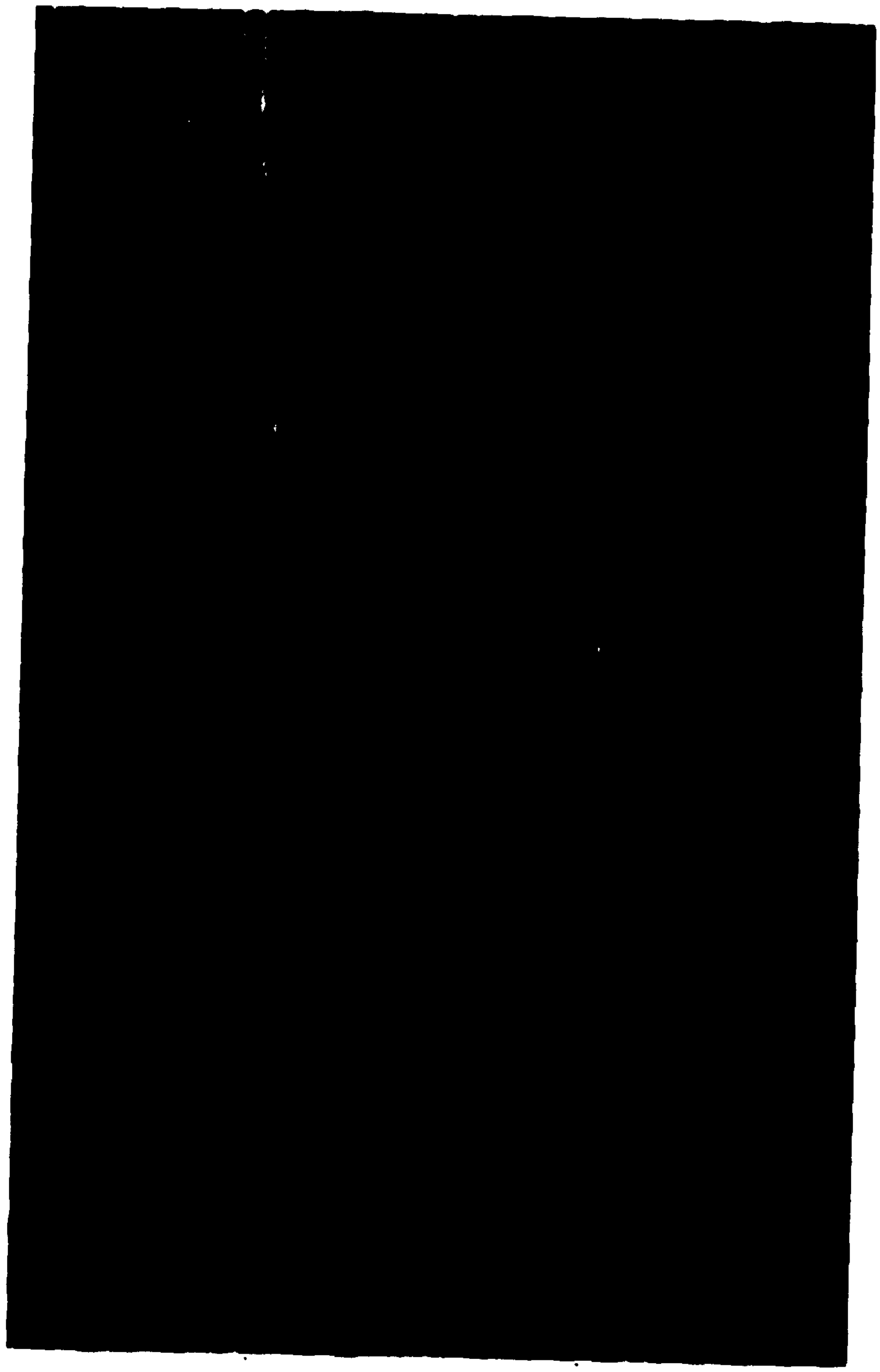


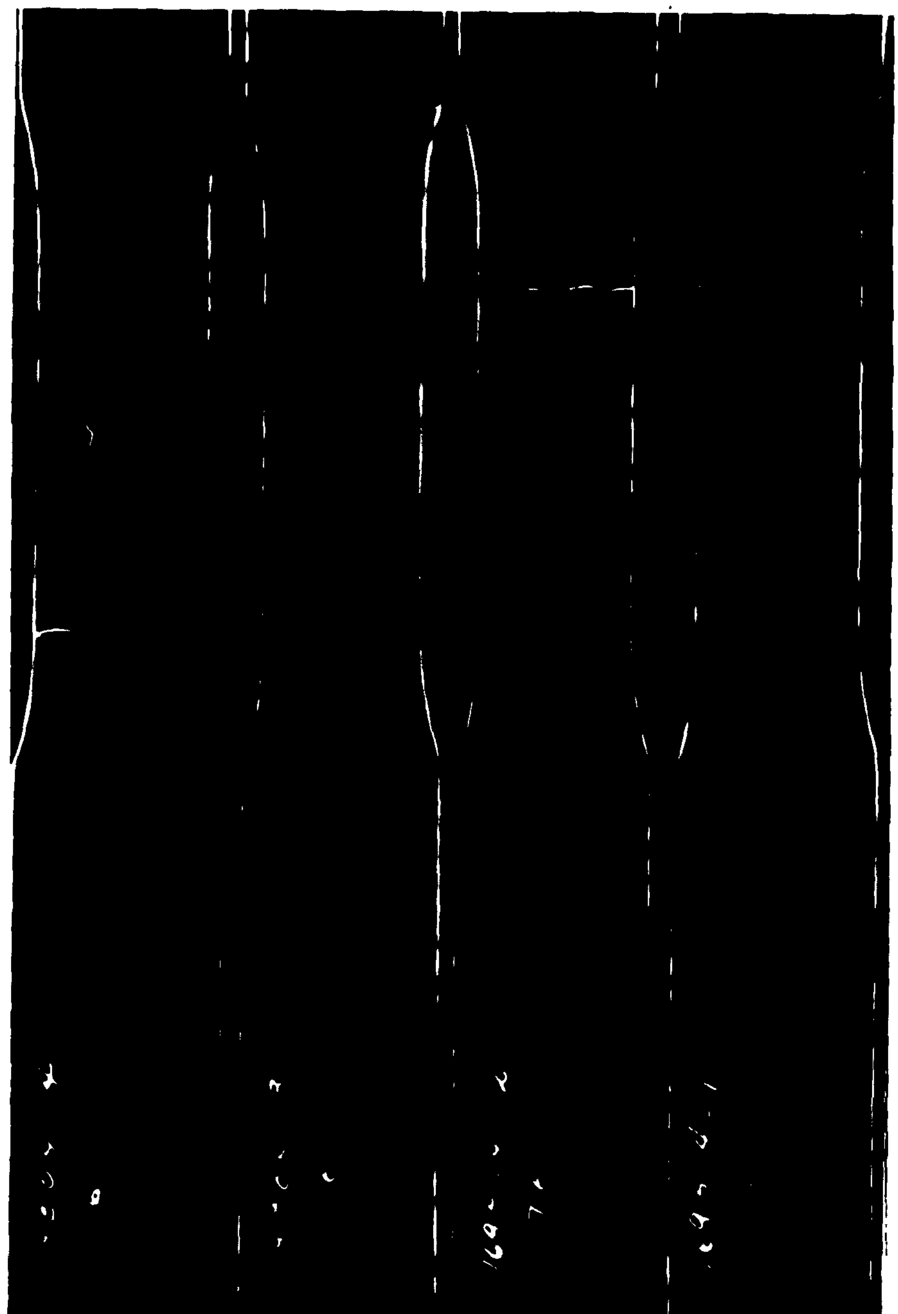


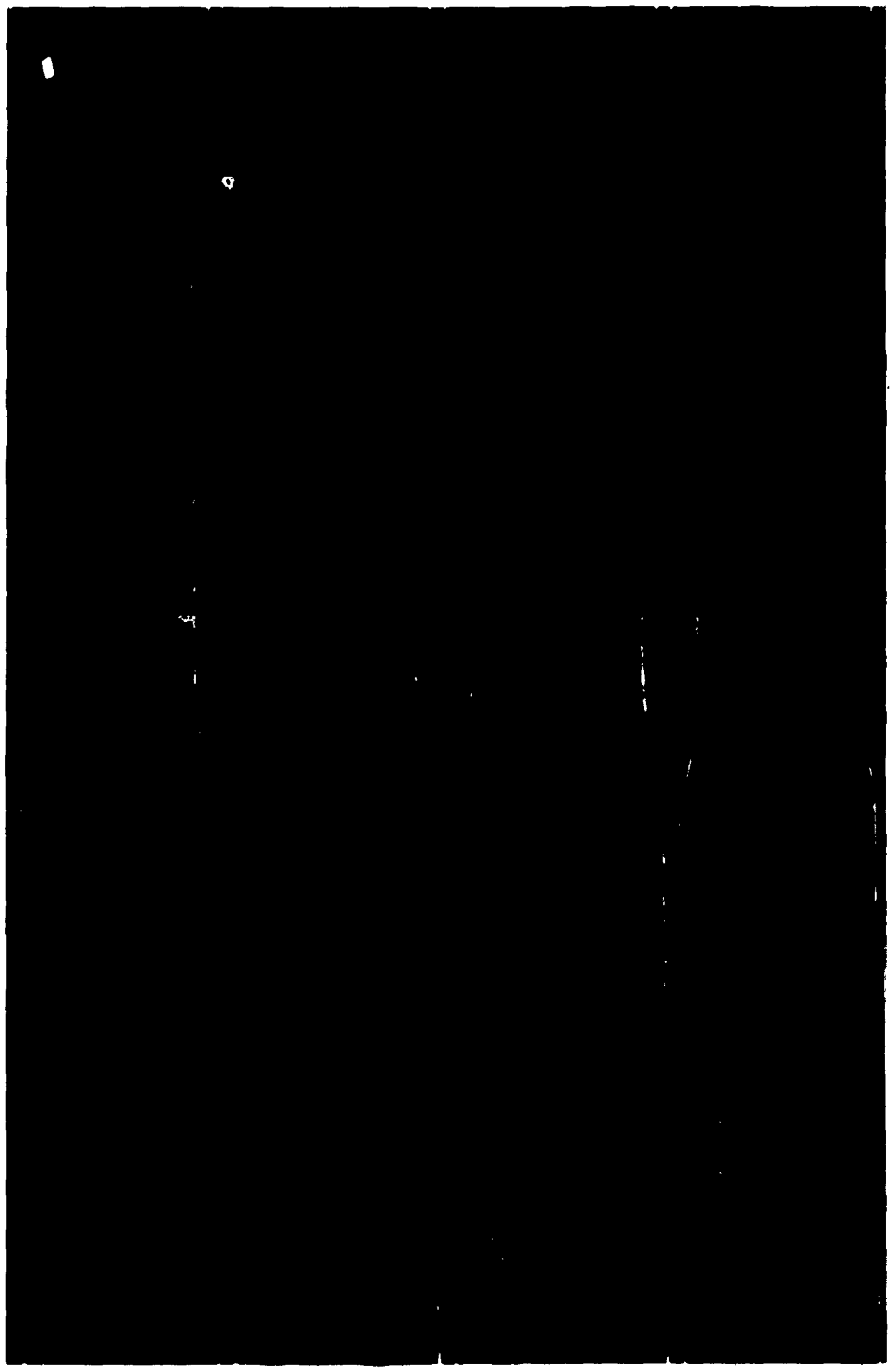


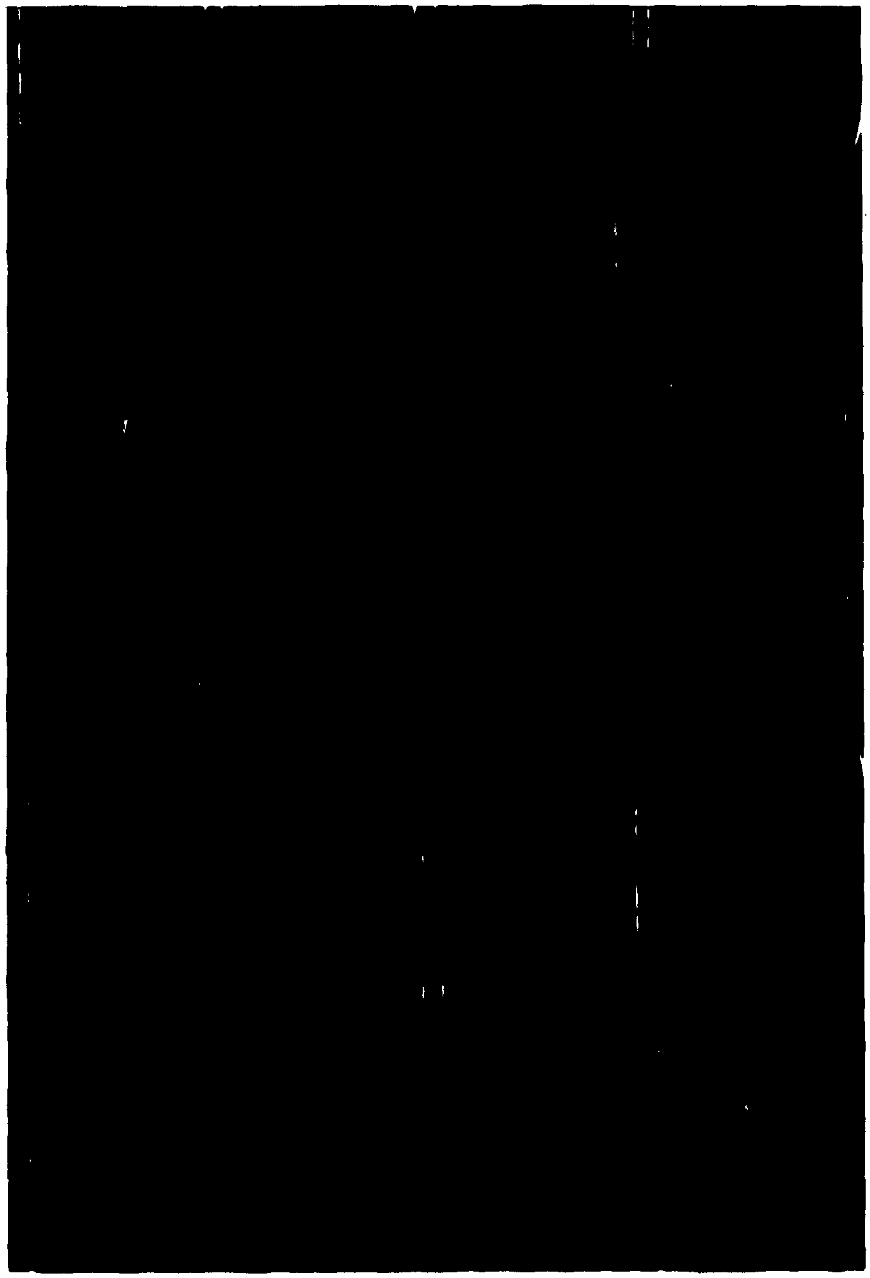


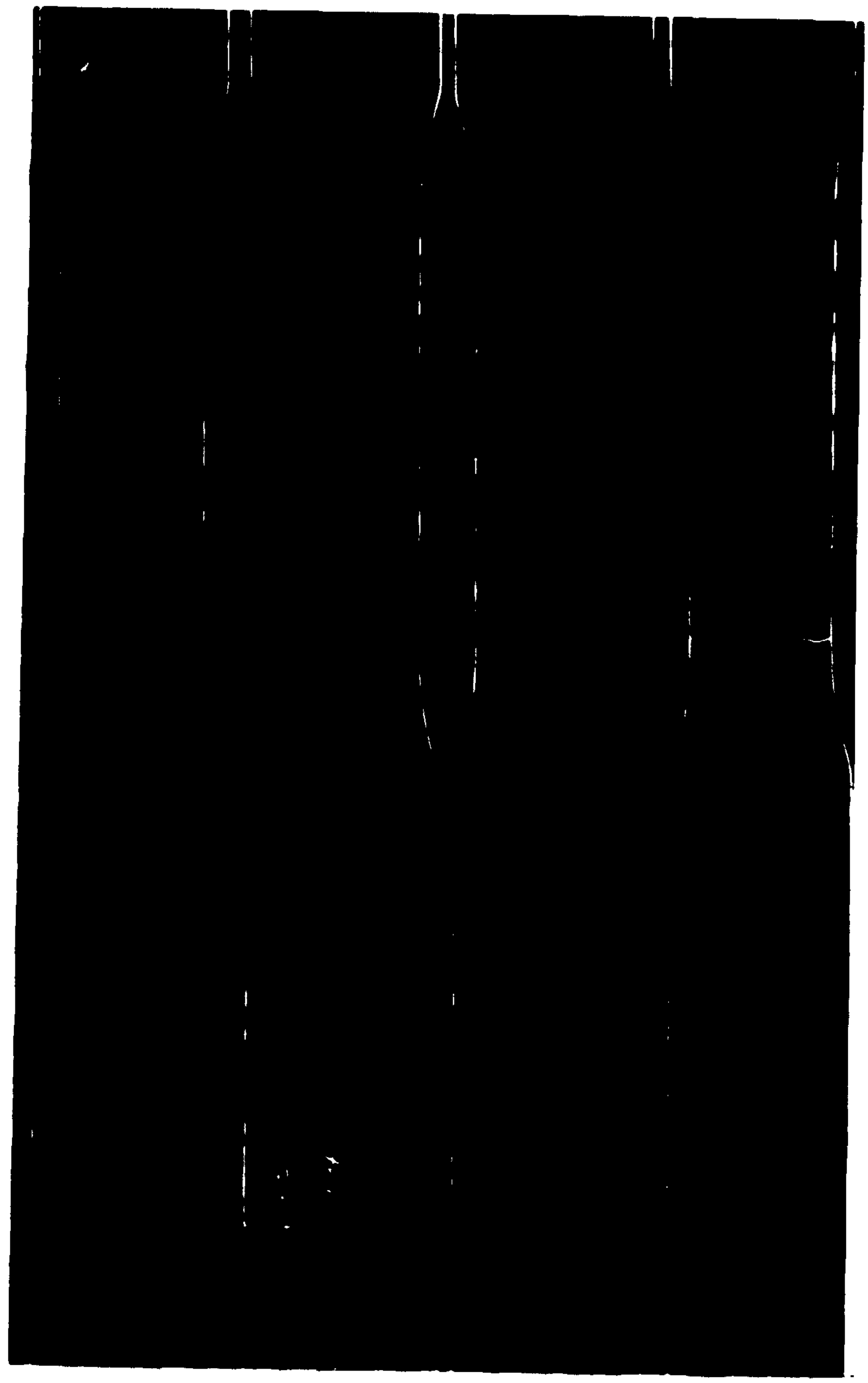


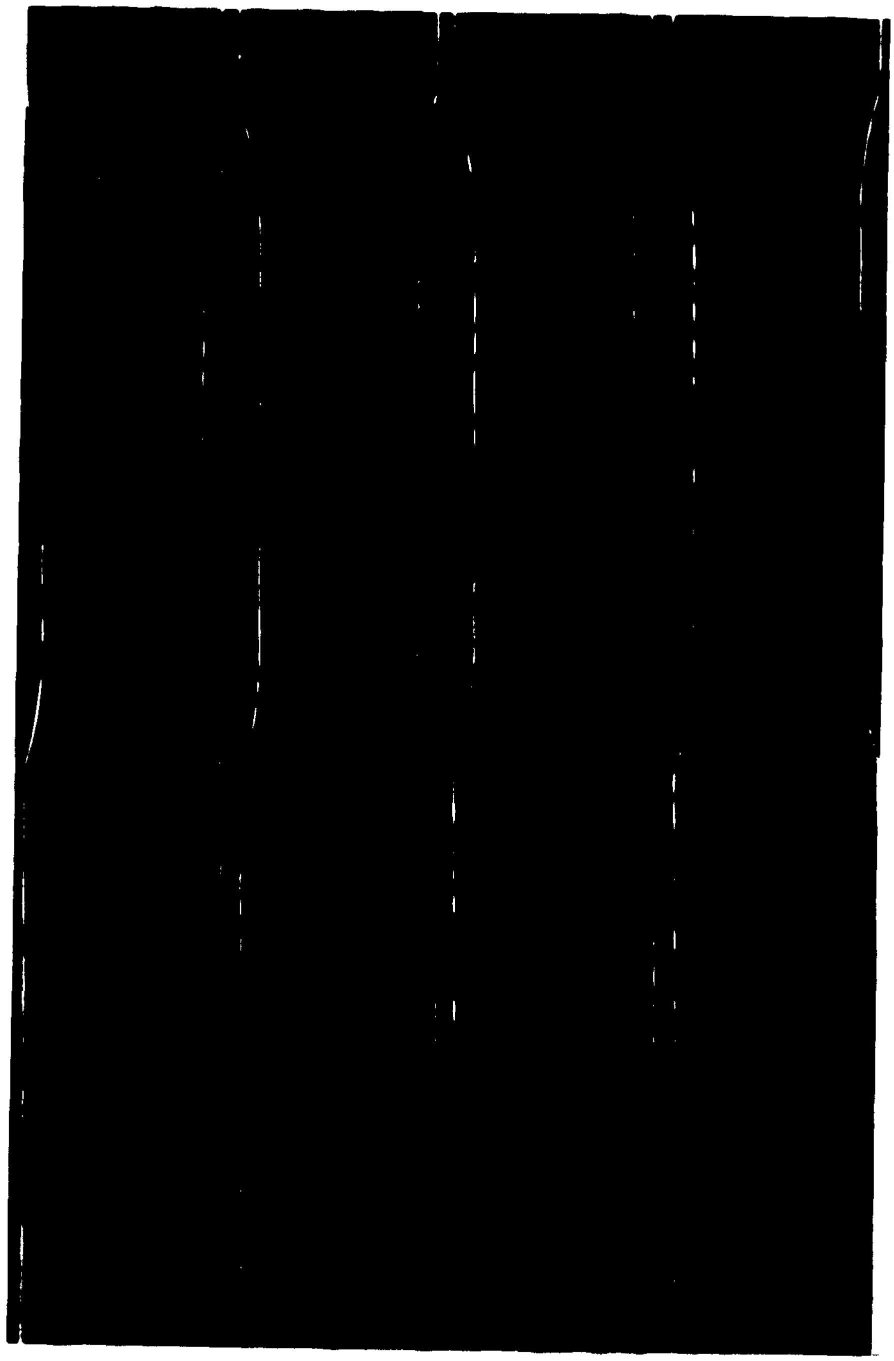


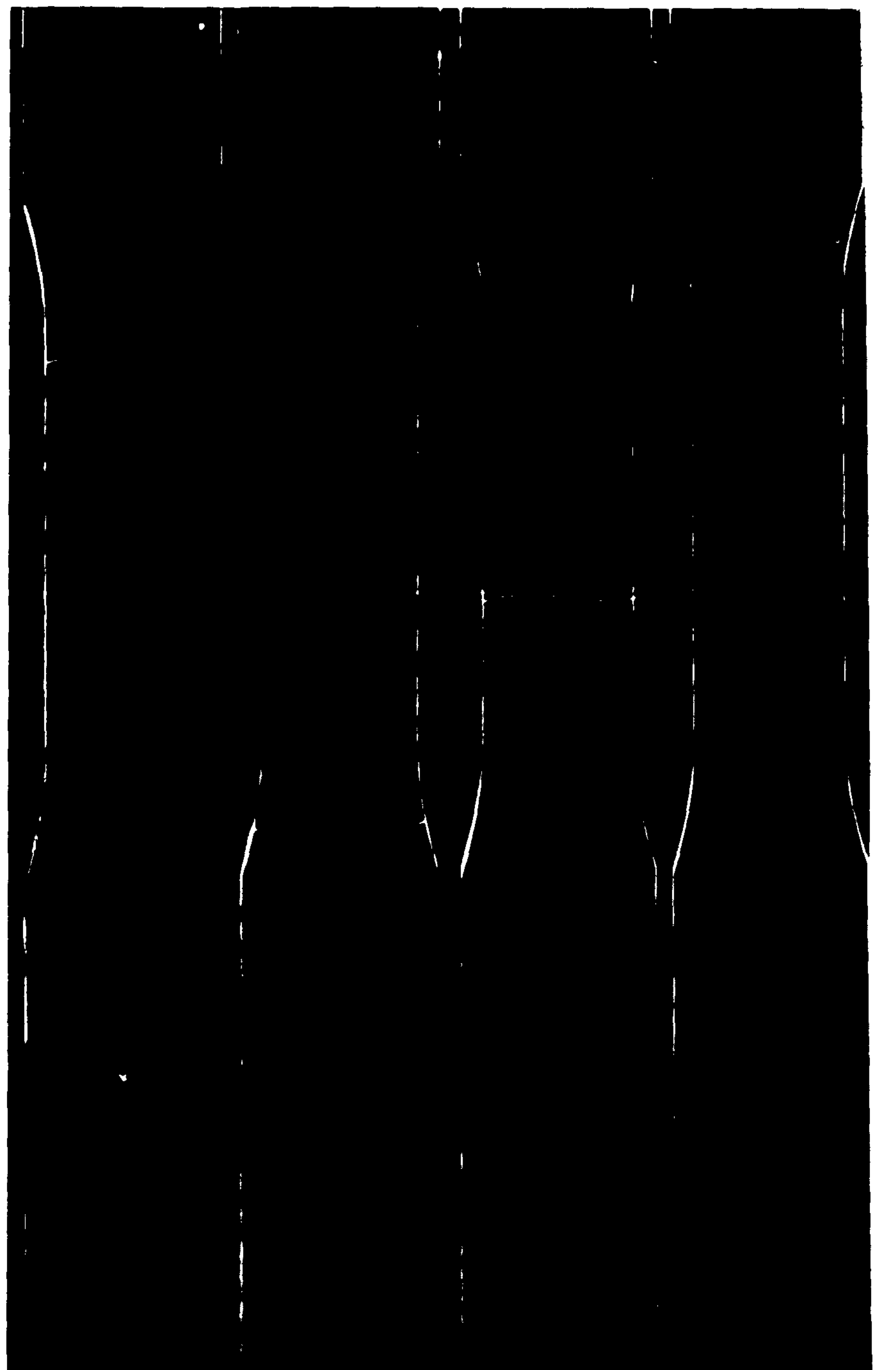


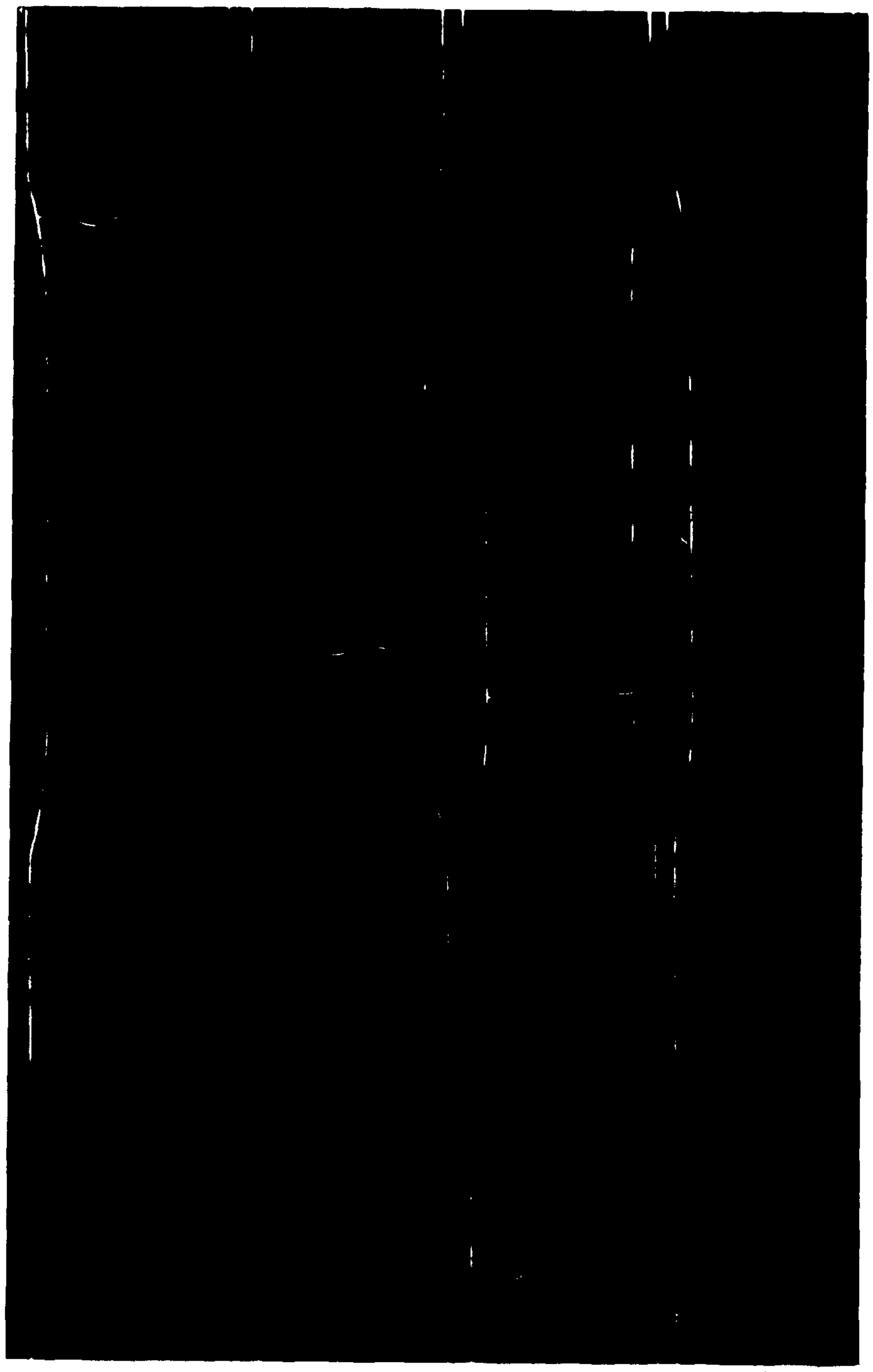












MECHANICAL PROPERTIES OF FS-1 MAGNESIUM

MATERIAL IDENTIFICATION (COML.)	MATERIAL STATUS
FS-1 Magnesium	Production
HEAT OR BATCH NUMBER	**FORM**
Unavailable	Sheet

PROCESSING CONDITION

H24 - Strain hardened and partially annealed

OBJECT OF TEST:	RAC DATA REF.
Determine effect of unstressed heating in room temperature strength.	ERMR 4080 dated July 9, 1957

SPECIMEN TYPE

Standard 0.5" wide sheet specimens-The same as Fed. Test Std 151 a Method 211.1 (May 1959)

TEST METHOD:

Tensile tests were conducted on a Baldwin-Emery SR-4 testing machine at a strain rate of .005 inches/inches/minute. Each specimen was subjected to unstressed heating and then tested at room temperature. The specimens were exposed to various temperatures ranging from 275° ± 5°F to 425° ± 5°F. The time of exposure varied between 5 minutes and 60 minutes.

Three different sheet thicknesses were selected for evaluation. These sheets were chosen so that each thickness represented a different as-received tensile strength. The variation in as-received tensile strength is denoted in the succeeding tables by H, M & L (high, medium and low, respectively).

ROOM TEMPERATURE TENSILE TEST DATA - AS RECEIVED CONDITION

Spec. No.	Thick-ness	U.T.S. K.S.I.	Y.T.S. K.S.I.	% Elong.
L-1	.0875	42.0	36.6	17.0
L-2	.0870	43.6	34.2	15.0
L-3	.0880	42.2	32.1	16.0
Avg.	-	42.6	34.3	16.0
M-1	.050	45.0	35.4	16.0
M-2	.050	44.8	35.9	18.5
M-3	.049	45.9	37.0	23.5
Avg.	-	44.9	36.1	19.3
H-1	.026	47.0	42.3	*3.5
H-2	.030	47.5	37.3	18.5
H-3	.026	51.7	42.3	12.5
Avg.	-	48.7	40.6	15.5
QQ-M-44 (a)		39.0 (min.)	29.0(min.)	4.0 (min.)

* Broke in gage mark - not averaged.

ROOM TEMPERATURE TENSILE TEST DATA AFTER UNSTRESSED HEATING

Spec. No.	Thick-ness	Exposure Condition	U.T.S. K.S.I.	Y.T.S. K.S.I.	% Elong.	% Decrease from As-Received U.T.S.	% Decrease from As-Received Y.T.S.
1L	.0887	275°F-5 min.	41.7	32.2	18.0		
2L	.0886		41.3	32.2	22.0		
3L	.0887		41.3	32.5	20.0		
Avg.	-		41.4	32.3	20.0	2.82	5.83
4M	.0496	275°F-5 min.	39.7	29.6	23.0		
5M	.0496		39.8	30.4	24.0		
6M	.0498		39.7	30.7	24.0		
Avg.			39.7	30.2	23.7	11.58	16.35
7H	.0263	275°F-5 min.	41.1	35.1	18.0		
8H	.0264		41.6	34.1	18.0		
9H	.0262		42.0	34.3	18.0		
Avg.	-		41.6	34.5	18.0	14.58	15.00
10L	.0885	275°F-10 min.	41.8	33.3	16.0		
11L	.0886		41.8	33.5	18.0		
12L	.0885		41.8	33.1	19.0		
Avg.	-		41.8	33.3	18.3	1.88	2.91
13H	.0260	275°F-10 min.	42.6	34.7	16.0		
14H	.0257		43.5	35.2	18.0		
15H	.0261		42.6	35.9	15.0		
Avg.			42.9	35.3	16.3	11.90	15.45
16M	.0495	275°F-10 min.	40.6	31.5	19.0		
17M	.0496		40.5	31.3	21.0		
18M	.0495		40.7	31.4	21.0		
Avg.	-		40.6	31.4	20.3	9.59	8.03
19M	.0497	275°F-15 min.	40.3	31.5	19.0		
20M	.0498		40.3	31.1	20.0		
21M	.0497		40.5	31.3	19.0		
Avg.	-		40.4	31.3	19.3	10.00	13.26
22H	.0259	275°F-15 min.	42.9	35.7	17.0		
23H	.0260		42.6	35.0	16.0		
24H	.0259		42.7	36.4	15.0		
Avg.	-		42.7	35.8	16.0	12.3	11.80
25L	.0886	275°F-15 min.	42.1	32.9	17.0		
26L	.0884		42.3	33.1	17.5		
27L	.0886		41.9	33.1	18.0		
Avg.	-		42.1	33.0	17.5	1.17	3.79

ROOM TEMPERATURE TENSILE TEST DATA AFTER UNSTRESSED HEATING

Spec. No.	Thick-ness	Exposure Condition	U.T.S. K.S.I.	Y.T.S. K.S.I.	% Elong.	% Decrease from As-Received U.T.S.	% Decrease from As-Received Y.T.S.
28M	.0500	275°F-30 min.	40.4	30.4	20.0		
29M	.0495		40.8	30.8	18.5		
30M	.0500		40.6	31.1	19.0		
Avg.	-		40.6	30.8	19.2	9.56	14.68
31H	.0263	275°F-30 min.	41.1	34.1	15.0		
32H	.0263		42.6	35.1	14.0		
33H	.0262		42.9	35.1	15.5		
Avg.	-		42.2	34.8	14.8	13.33	14.30
34L	.0888	275°F-30 min.	42.6	32.6	17.5		
35L	.0883		41.7	31.3	16.5		
36L	.0890		41.6	31.9	16.0		
Avg.	-		42.0	31.9	16.7	1.41	7.00
37M	.0497	275°F-60 min.	40.7	31.4	19.0		
38M	.0495		40.4	31.4	17.0		
39M	.0498		40.6	31.1	20.0		
Avg.	-		40.8	31.3	18.7	9.13	14.00
40H	.0260	275°F-60 min.	42.6	34.5	17.5		
41H	.0260		42.9	34.3	17.0		
42H	.0259		42.9	34.8	14.0		
Avg.	-		42.8	34.5	16.2	12.10	15.00
43L	.0886	275°F-60 min.	41.7	31.3	18.0		
44L	.0886		41.6	32.4	17.0		
45L	.0886		41.7	32.7	17.5		
Avg.	-		41.7	32.1	17.5	2.11	6.42
46L	.0885	300°F-5 min.	42.1	32.4	20.0		
47L	.0885		42.5	33.7	17.0		
48L	.0887		42.1	32.7	20.0		
Avg.	-		42.2	32.9	19.0	.94	4.08
49H	.0260	300°F-5 min.	43.0	34.9	14.0		
50H	.0260		43.4	34.9	16.0		
51H	.0259		43.1	33.9	15.0		
Avg.	-		43.2	34.6	15.0	11.29	14.80
52M	.0496	300°F-5 min.	40.9	31.3	20.0		
53M	.0496		41.1	31.7	19.0		
54M	.0498		40.8	31.1	18.0		
Avg.	-		40.9	31.4	19.0	8.90	13.00

ROOM TEMPERATURE TENSILE TEST DATA AFTER UNSTRESSED HEATING

Spec. No.	Thick-ness	Exposure Condition	U.T.S. K.S.I.	Y.T.S. K.S.I.	% Elong.	% Decrease from As-Received U.T.S.	% Decrease from As-Received Y.T.S.
55H	.0260	300°F-10 min.	42.9	35.5	17.0		
56H	.0259		43.1	35.6	15.0		
57H	.0259		43.4	35.5	14.0		
Avg.	-		43.1	35.5	15.3	11.50	12.55
58M	.0500	300°F-10 min.	40.6	31.1	17.5		
59M	.0500		40.6	31.4	18.5		
60M	.0500		40.8	31.7	19.0		
Avg.	-		40.7	31.4	18.3	9.36	13.00
61L	.0884	300°F-10 min.	42.5	34.0	18.0		
62L	.0887		42.5	34.0	19.0		
63L	.0884		42.1	32.7	19.0		
Avg.	-		42.4	33.6	18.7	0.47	2.04
64H	.0261	300°F-15 min.	42.8	34.9	15.0		
65H	.0258		42.7	35.5	16.0		
66H	.0262		42.7	35.1	17.0		
Avg.			42.7	35.2	16.0	12.31	13.31
67M	.0500	300°F-15 min.	40.6	31.4	17.5		
68M	.0500		40.6	30.9	19.0		
69M	.0500		40.6	31.1	19.0		
Avg.	-		40.6	31.1	18.5	9.57	13.83
70L	.0888	300°F-15 min.	42.2	33.2	16.0		
71L	.0890		41.9	33.9	19.0		
72L	.0890		42.2	34.3	18.0		
Avg.	-		42.1	33.8	17.7	1.17	1.38
73L	.0883	300°F-30 min.	41.9	31.9	16.5		
74L	.0886		41.9	33.2	14.5		
75L	.0885		42.6	34.2	15.0		
Avg.			42.1	33.1	15.3	1.17	2.96
76M	.0495	300°F-30 min.	41.1	31.9	17.5		
77M	.0497		40.9	32.4	18.5		
78M	.0496		40.9	31.4	17.5		
Avg.			41.0	31.9	17.8	1.17	296
79H	.0261	300°F-30 min.	43.1	34.1	15.0		
80H	.0256		43.1	36.2	12.5		
81H	.0257		43.0	34.1	15.0		
Avg.			43.1	34.8	14.2	8.68	11.62

ROOM TEMPERATURE TENSILE TEST DATA AFTER UNSTRESSED HEATING

Spec. No.	Thick-ness	Exposure Condition	U.T.S. K.S.I.	Y.T.S. K.S.I.	% Elong.	% Decrease from As-Received U.T.S.	% Decrease from As-Received Y.T.S.
82H	.0264	300°F-60 min.	42.4	33.9	15.0		
83H	.0260		43.4	35.6	15.5		
84H	.0261		43.5	34.6	15.5		
Avg.			43.1	34.7	15.3	11.50	14.50
85L	.0883	300°F-60 min.	42.0	32.8	19.0		
86L	.0884		42.2	31.4	16.5		
87L	.0885		42.4	31.9	17.5		
Avg.			42.2	32.2	17.7	0.94	6.12
88M	.0496	300°F-60 min.	40.9	30.9	16.5		
89M	.0496		41.9	31.1	18.0		
90M	.0493		40.7	31.5	18.0		
Avg.			41.2	31.2	17.5	8.24	13.55
91L	.0883	325°F-5 min.	42.4	31.7	17.0		
92L	.0883		42.4	32.7	16.0		
93L	.0885		42.4	32.6	19.0		
Avg.			42.4	32.3	17.3	.47	4.92
94M	.0496	325°F-5 min.	41.2	30.6	20.0		
95M	.0496		41.3	31.5	20.0		
96M	.0494		41.4	31.5	20.0		
Avg.			41.3	31.2	20.0	8.01	8.59
97H	.0260	325°F-5 min.	42.8	34.2	16.0		
98H	.0260		42.8	33.1	17.0		
99H	.0260		43.0	33.9	15.5		
Avg.			42.9	33.7	16.2	11.95	17.00
100L	.0885	325°F-10 min.	41.9	32.6	20.0		
101L	.0884		42.0	30.5	17.0		
102L	.0884		41.8	30.5	20.0		
Avg.			41.9	31.2	19.0	1.64	9.04
103H	.0255	325°F-10 min.	42.8	34.4	16.0		
104H	.0256		42.9	34.4	16.0		
105H	.0261		43.4	33.2	13.0		
Avg.			43.0	34.0	15.0	11.70	16.25
106M	.0495	325°F-10 min.	41.7	30.9	18.0		
107M	.0496		41.1	31.5	19.0		
108M	.0497		40.9	31.2	18.0		
Avg.			41.2	31.2	18.3	8.25	13.55

ROOM TEMPERATURE TENSILE TEST DATA AFTER UNSTRESSED HEATING

Spec. No.	Thick-ness	Exposure Condition	U.T.S. K.S.I.	Y.T.S. K.S.I.	% Elong.	% Decrease from As-Received U.T.S.	% Decrease from As-Received Y.T.S.
109L	.0884	325°F-15 min.	42.0	30.5	17.0		
110L	.0883		42.1	31.0	17.0		
111L	.0884		4[illegible].4	32.7	18.0		
Avg.			42.2	31.7	17.3	0.94	7.50
112M	.0496	325°F-15 min.	41.3	31.1	19.0		
113M	.0495		40.9	30.5	19.0		
114M	.0496		41.3	30.9	19.0		
Avg.			41.2	30.8	19.0	8.24	15.45
115H	.0260	325°F-15 min.	43.1	33.9	14.5		
116H	.0260		43.1	35.4	17.0		
117H	.0260		42.6	34.2	18.0		
Avg.			42.9	34.5	16.5	11.60	15.00
118M	.0497	325°F-30 min.	40.9	31.3	20.0		
119M	.0495		40.7	30.4	21.0		
120M	.0497		40.5	30.7	21.0		
Avg.			40.7	30.8	20.7	9.35	14.70
121H	.0257	325°F-30 min.	42.8	33.8	17.0		
122H	.0256		42.9	35.0	18.0		
123H	.0262		42.6	34.9	13.0		
Avg.			42.8	34.6	16.0	12.10	14.75
124L	.0885	325°F-30 min.	42.0	31.0	20.5		
125L	.0888		41.8	32.1	20.5		
126L	.0888		41.5	32.4	20.5		
Avg.			41.8	32.1	20.5	1.87	6.42
127H	.0260	325°F-60 min.	42.3	33.5	19.0		
128H	.0257		42.6	34.7	19.0		
129H	.0262		42.5	33.2	16.5		
Avg.			42.5	33.8	18.2	12.75	16.70
130M	.0498	325°F-60 min.	40.1	30.6	22.5		
131M	.0500		39.5	29.5	22.5		
132M	.0497		39.8	29.8	23.0		
Avg.			39.8	30.0	22.7	11.36	16.90
133L	.0886	325°F-60 min.	40.9	31.8	24.5		
134L	.0886		41.1	31.9	21.0		
135L	.0886		40.6	30.9	22.0		
Avg.			40.9	31.5	22.3	4.00	8.16

ROOM TEMPERATURE TENSILE TEST DATA AFTER UNSTRESSED HEATING

Spec. No.	Thick-ness	Exposure Condition	U.T.S. K.S.I.	Y.T.S. K.S.I.	% Elong.	% Decrease from As-Received U.T.S.	% Decrease from As-Received Y.T.S.
136H	.0262	350°F-5 min.	42.7	32.4	17.0		
137H	.0261		42.8	33.5	16.0		
138H	.0257		43.5	35.1	14.0		
Avg.			43.0	33.7	15.7	11.70	17.00
139M	.0497	350°F-5 min.	40.9	31.3	19.0		
140M	.0496		41.0	31.2	17.0		
141M	.0495		41.2	31.5	18.0		
Avg.			41.0	31.3	18.0	8.69	13.30
142L	.0887	350°F-5 min.	42.3	32.2	19.5		
143L	.0890		42.7	32.0	19.5		
144L	.0883		42.2	32.2	18.0		
Avg.			42.4	32.1	19.0	0.47	6.40
145H	.0259	350°F-10 min.	43.3	31.8	15.5		
146H	.0254		44.1	33.0	13.0		
147H	.0255		43.6	34.2	15.5		
Avg.			43.7	33.0	14.7	10.25	18.70
148M	.0493	350°F-10 min.	41.3	30.3	18.0		
149M	.0496		41.3	30.6	18.0		
150M	.0498		41.1	29.7	18.0		
Avg.			41.2	30.2	18.0	8.69	17.20
151L	.0884	350°F-10 min.	42.5	30.3	19.5		
152L	.0884		42.1	32.3	22.0		
153L	.0883		42.5	31.4	18.5		
Avg.			42.4	31.3	20.0	10.25	18.70
154H	.0249	350°F-15 min.	44.2	33.7	15.5		
155H	.0248		44.5	34.8	16.0		
156H	.0262		43.0	33.1	15.0		
Avg.			43.9	33.9	15.5	9.87	16.50
157M	.0497	350°F-15 min.	40.9	29.1	19.5		
158M	.0497		40.9	29.1	19.5		
159M	.0494		41.0	29.2	18.0		
Avg.			40.9	29.1	19.0	8.91	19.40
160L	.0884	350°F-15 min.	41.9	30.2	20.0		
161L	.0886		41.4	28.6	20.0		
162L	.0889		42.0	30.5	19.5		
Avg.			41.8	29.8	19.8	7.88	13.10

ROOM TEMPERATURE TENSILE TEST DATA AFTER UNSTRESSED HEATING

Spec. No.	Thick-ness	Exposure Condition	U.T.S. K.S.I.	Y.T.S. K.S.I.	% Elong.	% Decrease from As-Received U.T.S.	% Decrease from As-Received Y.T.S.
163H	.0258	350°F-30 min.	42.2	33.3	18.0		
164H	.0260		42.2	32.7	21.0		
165H	.0262		41.4	31.5	18.5		
Avg.			41.9	32.5	19.2	13.95	12.00
166M	.0499	350°F-30 min.	39.1	28.7	23.0		
167M	.0493		39.5	29.4	24.5		
168M	.0497		38.9	28.8	24.5		
Avg.			39.2	29.0	24.0	12.70	19.65
169L	.0888	350°F-30 min.	40.3	30.5	23.5		
170L	.0888		40.4	30.1	23.0		
171L	.0882		40.7	30.5	24.0		
Avg.			40.5	30.4	23.5	4.92	11.34
172H	.0263	350°F-60 min.	40.3	30.7	21.0		
173H	.0260		40.9	31.7	21.0		
174H	.0261		40.7	30.9	21.5		
Avg.			40.6	31.2	21.5	16.65	23.10
175M	.0498	350°F-60 min.	39.3	28.7	25.0		
176M	.0496		38.3	28.9	24.0		
177M	.0498		37.5	28.0	25.5		
Avg.			38.4	28.5	24.8	14.45	21.10
178L	.0886	350°F-60 min.	40.0	29.5	25.0		
179L	.0887		40.2	29.6	25.0		
180L	.0887		39.9	29.0	25.0		
Avg.			40.0	29.4	25.0	6.10	14.30
181H	.0258	375°F-5 min.	40.9	31.3	21.5		
182H	.0256		40.9	31.2	21.0		
183H	.0257		40.8	31.2	20.5		
Avg.			40.9	31.2	21.0	16.00	23.20
184M	.0496	375°F-5 min.	38.6	27.3	25.0		
185M	.0497		38.2	27.4	25.0		
186M	.0498		38.5	28.0	25.0		
Avg.			38.4	27.6	25.0	14.45	23.50
187L	.0885	375°F-5 min.	39.9	28.5	25.0		
188L	.0885		39.5	27.1	26.0		
189L	.0886		39.0	27.0	26.0		
Avg.			39.5	27.5	25.7	7.29	19.82

ROOM TEMPERATURE TENSILE TEST DATA AFTER UNSTRESSED HEATING

Spec. No.	Thick-ness	Exposure Condition	U.T.S. K.S.I.	Y.T.S. K.S.I.	% Elong.	% Decrease from As-Received U.T.S.	Y.T.S.
190H	.0262	375°F-10 min.	42.4	32.7	17.0		
191H	.0262		43.4	31.9	18.0		
192H	.0261		42.4	32.3	15.5		
Avg.			42.7	32.3	16.8	12.31	20.40
193M	.0496	375°F-10 min.	39.5	29.6	21.0		
194M	.0498		39.5	29.2	20.0		
195M	.0498		39.5	29.4	21.0		
Avg.			39.5	29.4	20.7	12.01	18.55
196L	.0885	375°F-10 min.	41.0	32.0	21.0		
197L	.0885		40.8	30.9	22.5		
198L	.0887		41.0	30.8	22.0		
Avg.			40.9	31.2	21.8	4.00	8.77
199H	.0263	375°F-15 min.	42.3	32.2	17.0		
200H	.0256		42.0	32.0	19.0		
201H	.0260		41.5	34.2	18.0		
Avg.			41.9	32.0	18.0	13.95	19.20
202M	.0497	375°F-15 min.	39.4	28.4	22.0		
203M	.0504		38.5	28.4	22.0		
204M	.0503		38.8	28.6	23.0		
Avg.			38.9	28.5	22.3	13.35	21.00
205L	.0884	375°F-15 min.	40.5	31.0	23.0		
206L	.0888		41.5	30.3	22.5		
207L	.0892		39.0	30.5	22.0		
Avg.			40.3	30.6	22.5	5.4	10.8
208H	.0257	375°F-30 min.	43.8	31.8	21.5		
209H	.0260		40.0	30.4	20.5		
210H	.0261		40.5	31.0	20.0		
Avg.			41.4	31.1	20.7	15.0	23.40
211M	.0496	375°F-30 min.	38.4	27.8	23.5		
212M	.0499		38.5	27.8	24.5		
213M	.0497		38.3	27.3	21.5		
Avg.			38.4	27.6	23.2	14.45	23.50
214L	.0888	375°F-30 min.	39.0	28.9	22.5		
215L	.0885		37.4	27.0	24.5		
216L	.0887		39.2	28.9	24.0		
Avg.			38.5	28.3	23.7	9.63	19.80

ROOM TEMPERATURE TENSILE TEST DATA AFTER UNSTRESSED HEATING

Spec. No.	Thick-ness	Exposure Conditon	U.T.S. K.S.I.	Y.T.S. K.S.I.	% Elong.	% Decrease from As-Received U.T.S.	% Decrease from As-Received Y.T.S.
217H	.026	375°F-60 min.	40.4	29.2	20.5		
218H	.026		39.3	29.0	21.0		
219H	.026		40.0	30.1	22.0		
Avg.			39.9	29.4	21.2	18.05	27.60
220M	.050	375°F-60 min.	37.9	27.7	23.5		
221M	.050		38.2	27.4	21.5		
222M	.050		37.9	27.5	23.0		
Avg.			38.0	27.6	22.7	15.21	23.50
223L	.0885	375°F-60 min.	39.0	28.4	24.0		
224L	.0885		39.5	28.1	24.5		
225L	.089		39.9	27.5	24.5		
Avg.			39.5	28.0	24.3	7.27	18.35
226M	.050	400°F-5 min.	39.7	28.5	22.0		
227M	.0505		39.1	29.0	22.0		
228M	.0505		39.4	29.9	20.5		
Avg.			39.4	29.1	21.5	12.25	19.40
229H	.026	400°F-5 min.	42.4	30.2	17.0		
230H	.026		42.8	31.8	17.5		
231H	.026		42.0	30.8	19.5		
Avg.			42.4	30.9	17.7	12.95	23.90
232L	.089	400°F-5 min.	40.9	33.3	20.5		
233L	.089		40.9	28.7	21.0		
234L	.089		40.8	30.0	20.5		
Avg.			40.9	30.7	20.7	3.99	10.50
235L	.089	400°F-10 min.	39.0	27.0	22.5		
236L	.089		39.2	28.0	24.5		
237L	.088		39.5	27.9	23.5		
Avg.			39.2	27.6	23.5	7.98	19.50
238H	.026	400°F-10 min.	40.1	29.1	21.0		
239H	.026		39.1	28.5	21.5		
240H	.026		39.7	29.6	21.0		
Avg.			40.0	29.1	21.2	17.85	20.30
241M	.050	400°F-10 min.	37.2	30.0	25.0		
242M	.050		37.5	26.8	25.9		
243M	.050		37.9	26.6	25.9		
Avg.			37.5	27.8	25.6	16.45	23.00

ROOM TEMPERATURE TENSILE TEST DATA AFTER UNSTRESSED HEATING

Spec. No.	Thick-ness	Exposure Condition	U.T.S. K.S.I.	Y.T.S. K.S.I.	% Elong.	% Decrease from As-Received U.T.S.	% Decrease from As-Received Y.T.S.
244M	.050	400°F-15 min.	37.6	26.2	26.5		
245M	.0505		37.7	26.4	28.3		
246M	.050		37.9	27.1	26.0		
Avg.			37.7	26.6	26.9	16.00	26.30
247M	.0252	400°F-15 min.	42.1	32.5	12.0		
248M	.0251		40.7	29.9	13.0		
249M	.0252		40.7	30.0	12.0		
Avg.			41.2	30.8	12.3	15.40	24.10
250L	.084	400°F-15 min.	41.7	29.7	24.3		
251L	.0835		41.7	30.5	23.5		
252L	.084		41.1	29.9	24.3		
Avg.			41.5	30.0	24.0	16.91	12.52
253M	.5005	400°F-30 min.	37.6	28.0	24.0		
254M	.500		37.4	28.0	24.0		
255M	.5005		37.8	25.8	24.0		
Avg.			37.6	27.3	24.0	16.27	24.40
256H	.0251	400°F-30 min.	42.0	31.0	23.0		
257H	.02515		42.0	31.2	21.0		
258H	.0251		41.5	31.5	22.0		
Avg.			41.8	31.2	22.0	12.10	23.10
259L	.0890	400°F-30 min.	38.8	28.0	24.0		
260L	.0890		38.7	26.9	23.0		
261L	.0890		38.6	27.8	24.0		
Avg.			38.7	27.6	23.3	9.15	19.50
262L	.0839	425°F-5 min.	40.9	31.8	16.0		
263L	.0836		40.3	31.2	18.0		
264L	.0889		41.0	31.7	14.0		
Avg.			40.7	31.6	16.0	4.46	7.87
265H	.0255	425°F-5 min.	43.3	35.5	16.0		
266H	.0261		41.0	32.1	15.0		
267H	.0253		42.4	34.7	18.0		
Avg.			42.2	34.1	16.3	13.35	[illegible].00
268M	.0496	425°F-5 min.	34.6	29.7	21.0		
269M	.0498		39.4	30.0	21.0		
270M	.0497		39.7	30.6	21.0		
Avg.			37.9	30.1	21.0	15.60	16.61

ROOM TEMPERATURE TENSILE TEST DATA AFTER UNSTRESSED HEATING

Spec. No.	Thick-ness	Exposure Condition	U.T.S. K.S.I.	Y.T.S. K.S.I.	% Elong.	% Decrease from As-Received U.T.S.	Y.T.S.
271L	.0887	425°F-10 min.	38.5	33.5	26.0		
272L	.0884		39.3	28.7	27.0		
273L	.0887		39.7	28.8	24.0		
Avg.			39.2	30.3	25.7	7.98	11.65
274H	.0258	425°F-10 min.	40.0	28.7	22.0		
275H	.0256		39.8	28.1	22.0		
276H	.0256		39.5	28.1	22.0		
Avg.			39.8	28.3	22.0	18.42	30.3
277M	.0493	425°F-10 min.	37.8	26.4	24.0		
278M	.0496		37.3	27.1	24.0		
279M	.0497		37.3	27.6	23.0		
Avg.			37.5	27.0	23.7	16.49	25.2
280H	.0256	425°F-15 min.	40.4	30.7	24.0		
281H	.0261		40.1	30.0	21.0		
282H	.0261		39.7	29.7	20.0		
Avg.			40.1	30.1	21.7	17.65	25.81
283M	.0497	425°F-15 min.	38.2	27.5	24.0		
284M	.0498		38.7	27.0	23.0		
285M	.0496		38.5	28.7	25.0		
Avg.			38.5	27.7	24.0	14.25	23.30
286L	.0884	425°F-15 min.	39.0	29.5	23.0		
287L	.0884		39.2	28.6	22.0		
288L	.0884		39.5	28.8	22.0		
Avg.			39.2	29.0	22.3	7.98	13.08

MECHANICAL PROPERTIES OF 4 Al-4 Mn TITANIUM

MATERIAL IDENTIFICATION (COML.) AMS - 4925	**MATERIAL STATUS** Experimental
HEAT OR BATCH NUMBER See data below	**FORM** Bar and Billets

PROCESSING CONDITION

Annealed

OBJECT OF TEST Determine mechanical properties of bar and billets material at room temperature and 600°F	**RAC DATA REF.** ERMR 3324 dated April 18, 1956

SPECIMEN TYPE

Tension .505 Dia. and .252 Dia. specimens - same as ARTC-13-T, June 1959
Fatigue - See data below

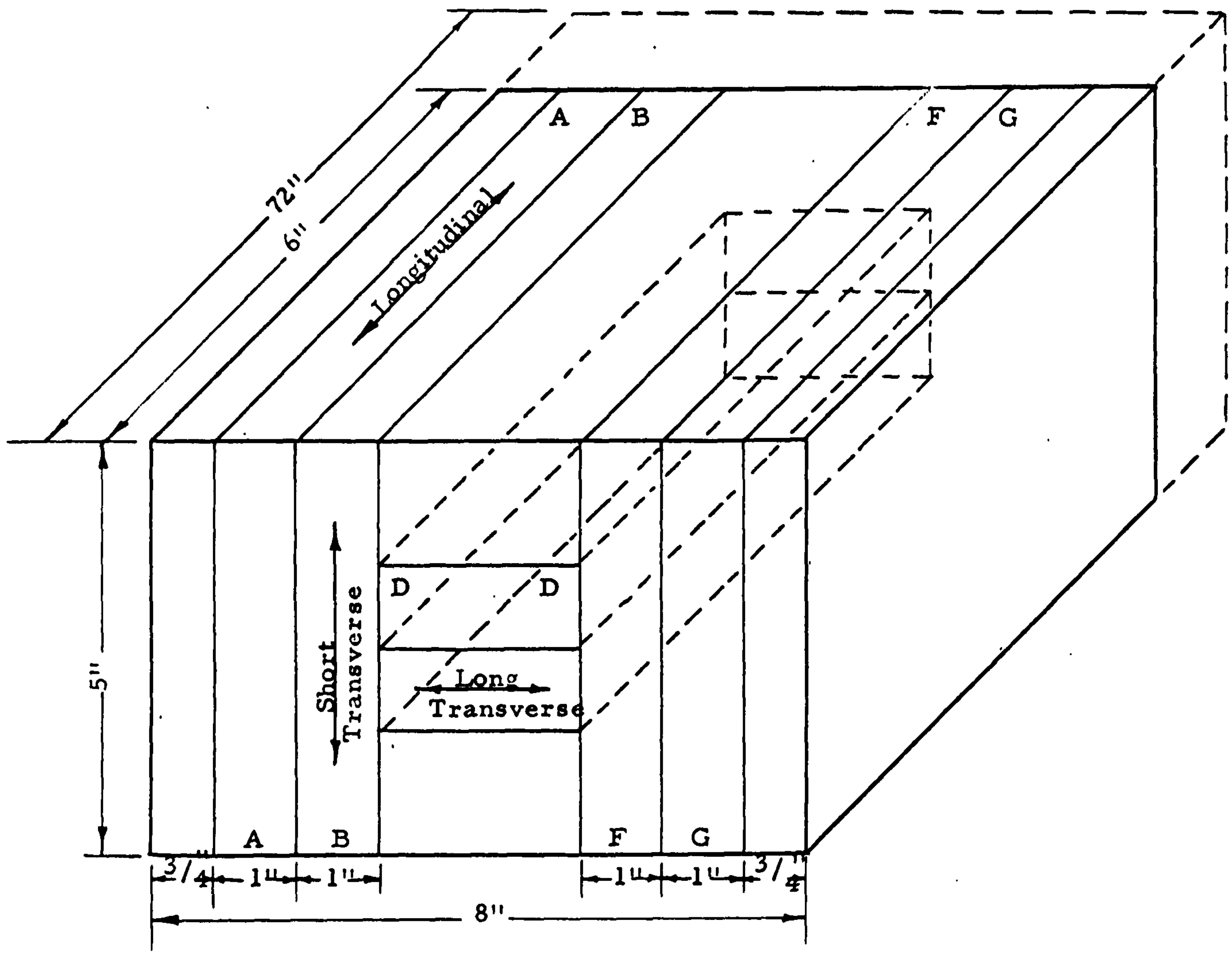
TEST METHOD:

Tensile properties at room temperature and 600°F (½ hour soak) and axial fatigue at room temperature were determined in the longitudinal, long transverse, and short transverse directions for three 5" x 8" x 72" billets. Long transverse tensile properties for three bars and two other billets drawn from RAC stock are also included.

Direction of test and billet orientation are illustrated on Page 2 for the 5" x 8" billet.

Tensile tests were conducted in the same manner as those specified in ARTC-13-T-1 (June 1959) and Fed. Test Method Std. No. 151a Method 211.1, dated 6 May 1959. Load deformation data were obtained, with a 2" extensometer, for all standard .505 Dia. Spec. The divider yield technique was used for .252 Dia. room temperature test specimens.

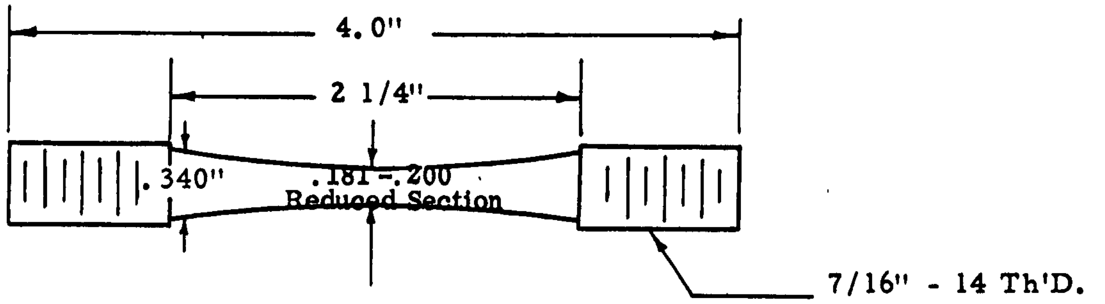
Fatigue testing was conducted on the type of specimens illustrated on Page 3. Since fatigue specimens had not been standardized, specimen "A" was initially selected for use. When number of these specimens broke outside the reduced section, in the threads or near the shoulder, specimen "B" was substituted to overcome this difficulty. Specimen "C" was utilized where sample size limitations dictated the use of a smaller type specimen. All specimens were designed to produce a minimum of stress concentration in the reduced sections. The fatigue testing was conducted at room temperature at a cycling rate of 1800 cpm and a stress ratio of R = 0.1.



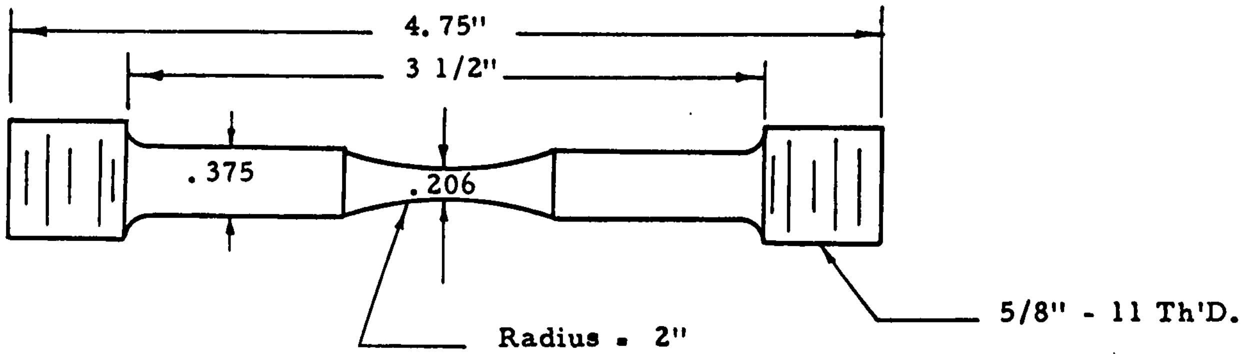
Testing Direction for extracted slabs:

AA and GG - Longitudinal
BB and FF - Short Transverse
DD and EE - Long Transverse

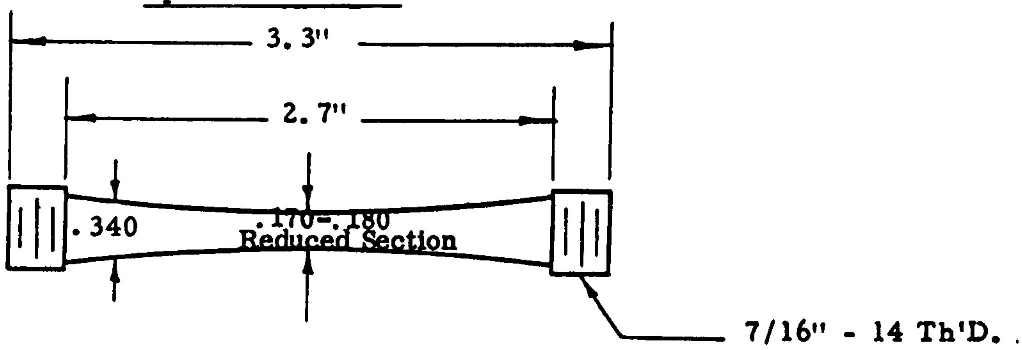
Billet Orientation



Specimen - "A"



Specimen - "B"



Specimen - "C"

Fatigue Specimens

REPUBLIC AVIATION CORPORATION
REPUBLIC AVIATION CORPORATION

TENSILE PROPERTIES OF 5"x8"x72" - BILLET #51025

Test Cond.	Direction of Test	ULT. K.S.I.	Yield K.S.I	Elongation % in 4D	Modulus x10[6]
Rm. Temp	Long	147.0	142.8**	17.0	-
		148.2	143.8**	17.0	-
		147.0	143.8	17.5	17.4
600°F		108.0	87.8	14.0	14.9
		112.0	99.0	17.0	16.7
Rm. Temp	Long Transverse	150.0	146.0*	13.0	-
		149.0	146.0*	10.0	-
		150.2	148.0*	10.0	-
600°F		107.0	-	14.0	-
		106.5	-	16.0	-
Rm. Temp	Short Transverse	146.0	144.0	8.0	17.7
		154.0	148.5	8.5	17.9
600°F		107.0	-	14.0	-

* Yield determined by divider method (Specimens too short for extensometer).

** Yield determined by divider method (Extensometer did not function properly).

TENSILE PROPERTIES OF 5"x8"x72" - BILLET #51077

Test Cond.	Direction of Test	ULT. K.S.I.	Yield K.S.I.	Elongation % in 4D	Modulus x10^6
Rm. Temp	Long	147.0	140.0	14.0	17.6
		146.1	143.6	16.0	17.0
		142.0	139.0	15.0	18.5
600°F		108.0	102.0	12.0	14.4
		104.0	86.0	11.0	17.6
		106.0	97.7	11.0	14.9
Rm. Temp	Long Transverse	142.0	138.0	10.0	18.2
		154.0	138.0	9.0	17.2
600°F		104.0	91.0	BOGL	16.8
		97.3	88.7	10.0	16.0
Rm. Temp	Short Transverse	154.0	151.0*	7.0	-

* Yield determined by divider method (Specimens too short for extensometer).

BOGL. - Broke outside of gage length.

TENSILE PROPERTIES OF 5"x8"x72" - BILLET #51009

Test Cond.	Direction of Test	ULT K.S.I.	Yield K.S.I.	Elongation % in 4D	Modulus $x10^6$
Rm. Temp	Long	152	144.5	17.0	16.5
		149.5	144.2	15.0	17.4
600°F		108.0	88.2	17.0	14.4
		104.0	87.8	18.0	14.4
Rm. Temp	Long Transverse	148.7	144.9*	11.0	17.4
		154.0	149.0*	5.0	-
		152.0	148.0*	10.0	-
600°F		112.0	-	11.0	-
Rm. Temp	Short Transverse	153.0	151.1	5.0	18.2
		151.0	148.0	4.0	18.0
600°F		106.0	102.0	10.0	14.3
		107.0	92.0	11.5	16.6

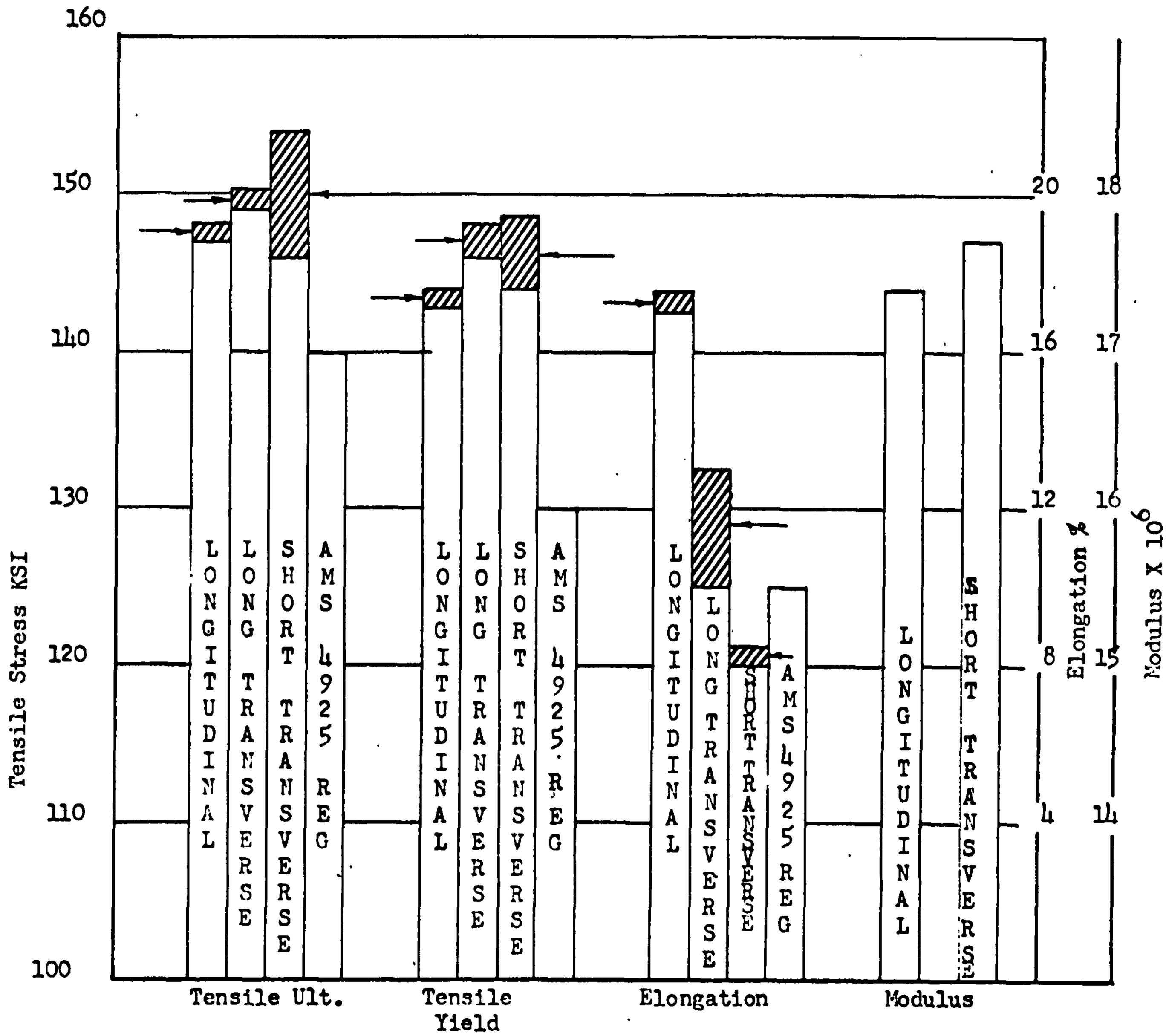
* Yield determined by divider method (Specimens too short for extensometer).

Long Transverse Mechanical Properties of Three Bars and Two Billets
Drawn From R.A.C. Stock

Classification	Nominal Size	Test Cond.	ULT. K.S.I.	Yield K.S.I.	Elong % in 4D	Mod. x10^6
Bar	2½"x7"	RT	154	152	12	16.6
			153	148	13	18.2
		600°F	109	95.6	13	15.4
			98	77.5	12	14.0
			109	104.5	15	16.3
			94	78.5	12	16.8
Bar	4.0"x5.6"	RT	148	140	10	16.9
			142	137	14	17.7
		600°F	96.5	84	13	16.6
			97.7	77.5	12	12.7
Bar	4.9"x9.5"	RT	141	136	13	17.3
			139	133.5	13.5	16.5
		600°F	99.2	84	15	13.7
			97.3	92.5	13	15.4
Billet	3.5"x6"	RT	151	147	10.5	17.2
			147	146	15	16.1
		600°F	99.7	85	14	16.8
			102	88	16	16.6

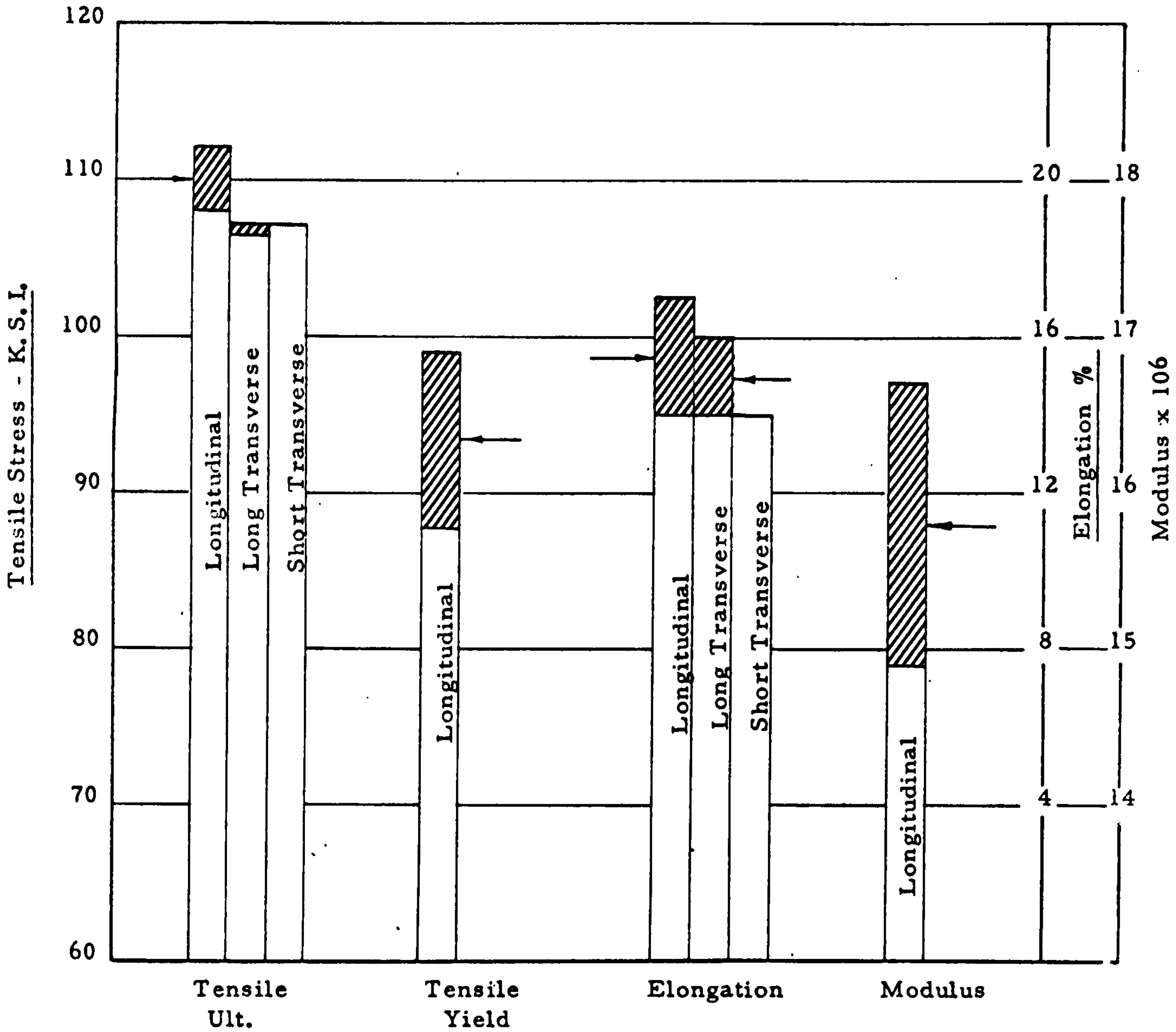
Long Transverse Mechanical Properties of Three Bars and Two Billets
Drawn From R.A.C. Stock

Classification	Nominal Size	Test Cond.	ULT K.S.I.	Yield K.S.I.	Elong. % in 4D	Mod. x10^6
Billet	5.5"x6"	RT	149	145	10	17.6
			153	152	10	18.8
			140	138	7.5	16.8
		600°F	96	86	13	15.6
			102	88	12	14.8



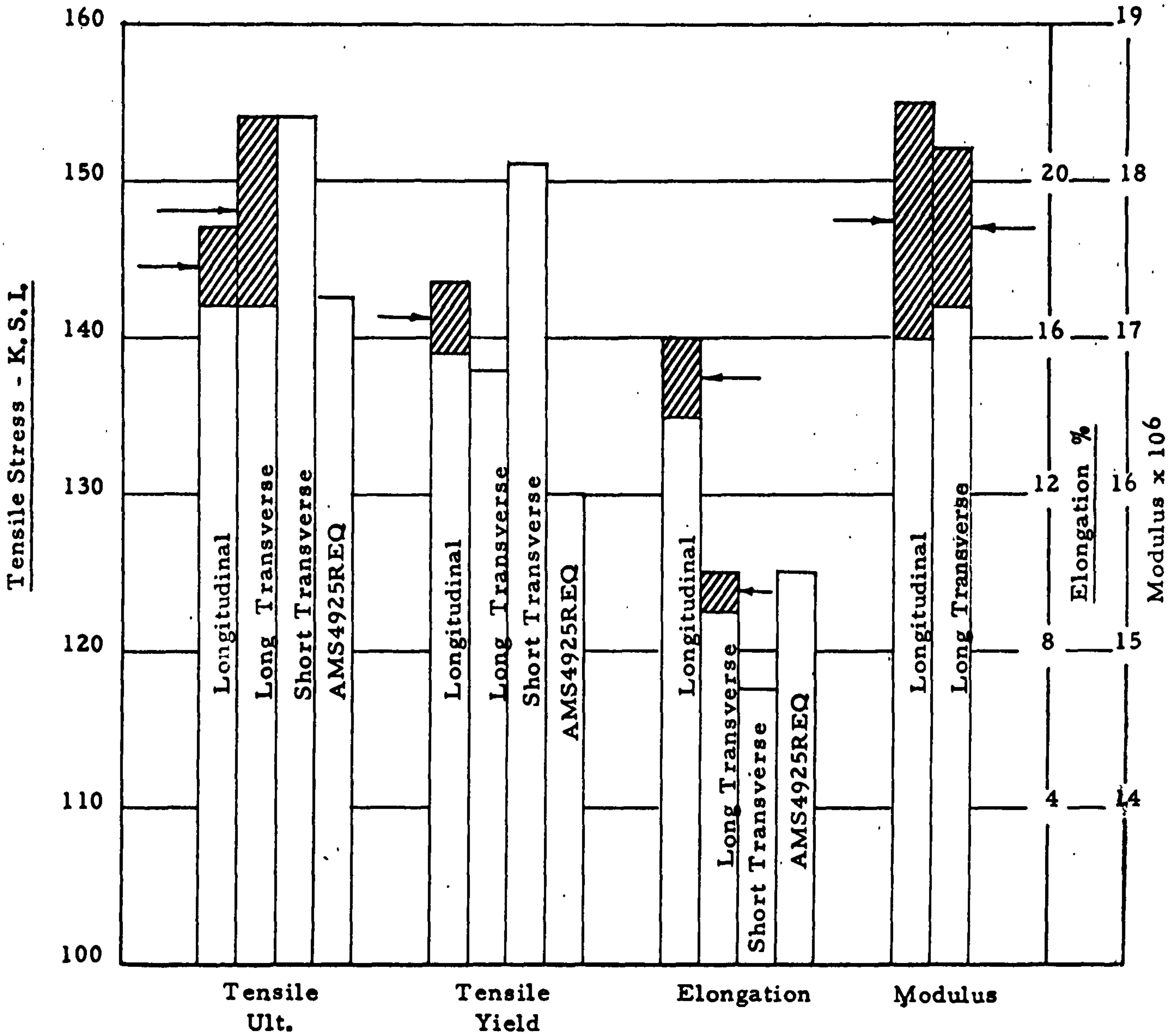
Legend - Shaded Area Indicates Range
Arrow indicates average value

Summary of Room Temperature Tensile Values
Billet #51025



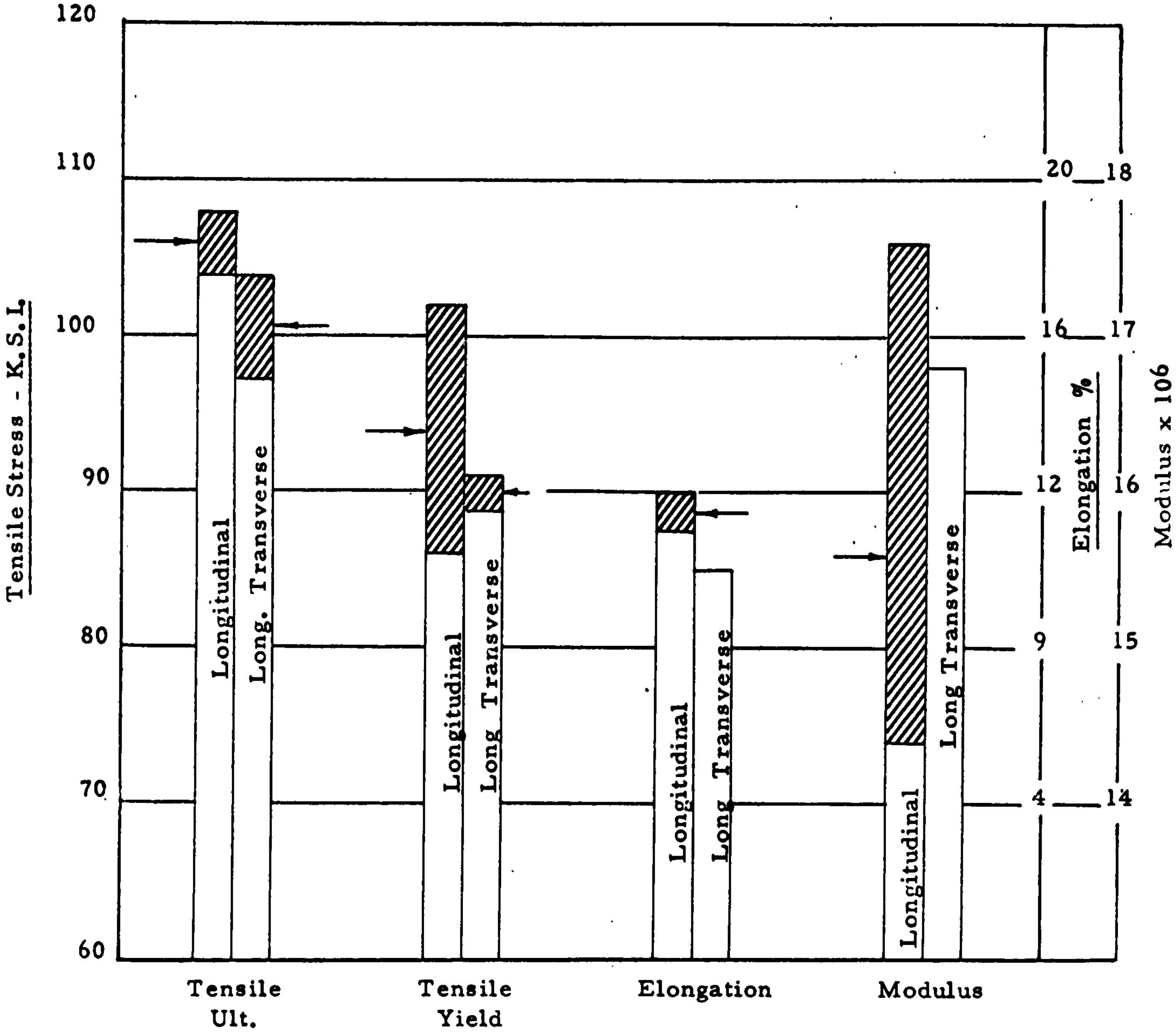
Legend - Shaded Area Indicates Range.
Arrow Indicates Average Values.

Summary of 600°F Tensile Values - Billet #51025



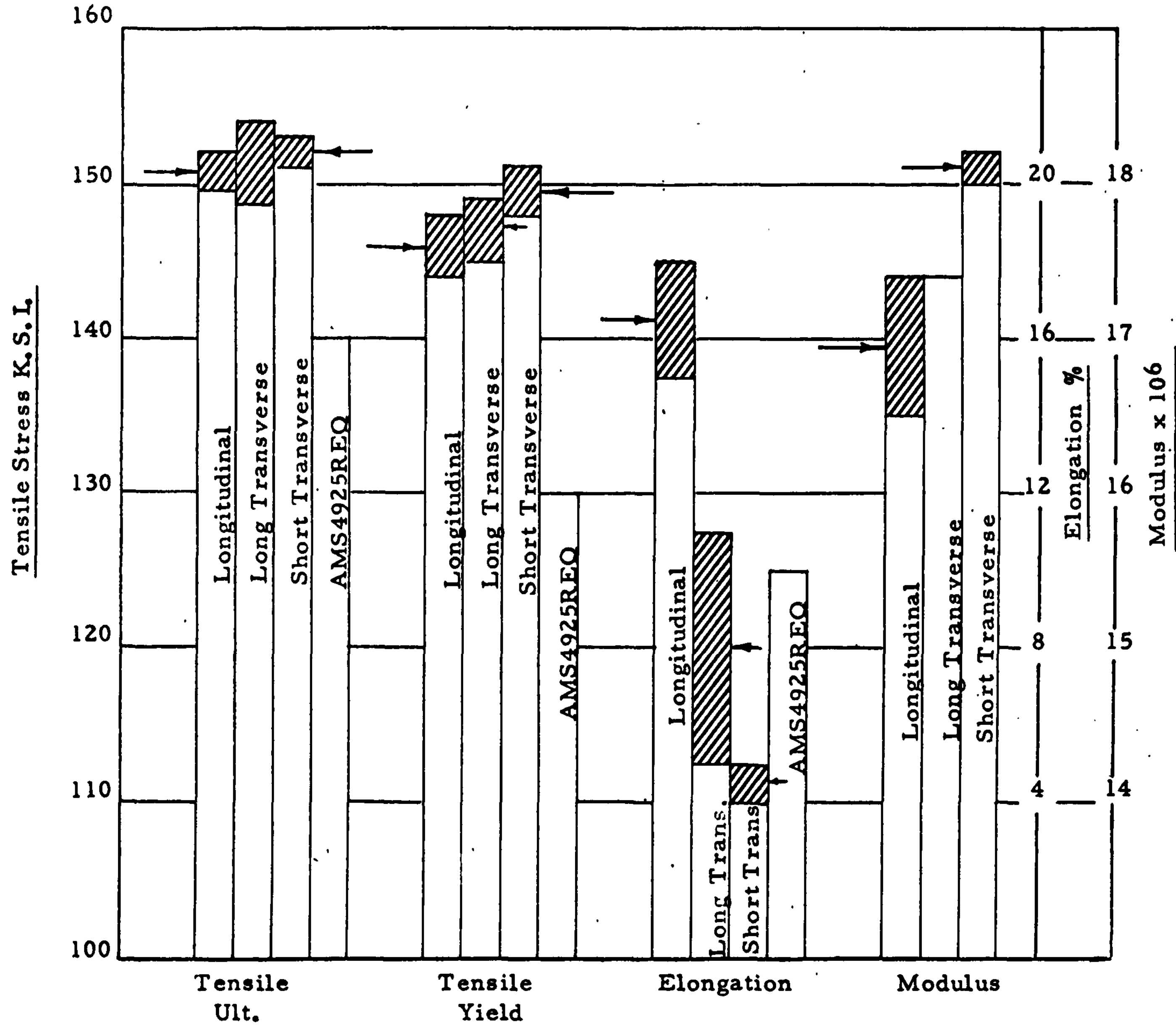
Legend - Shaded Area Indicates Range.
Arrow Indicates Average Values.

Summary of Room Temperature Tensile Values - Billet # 50077



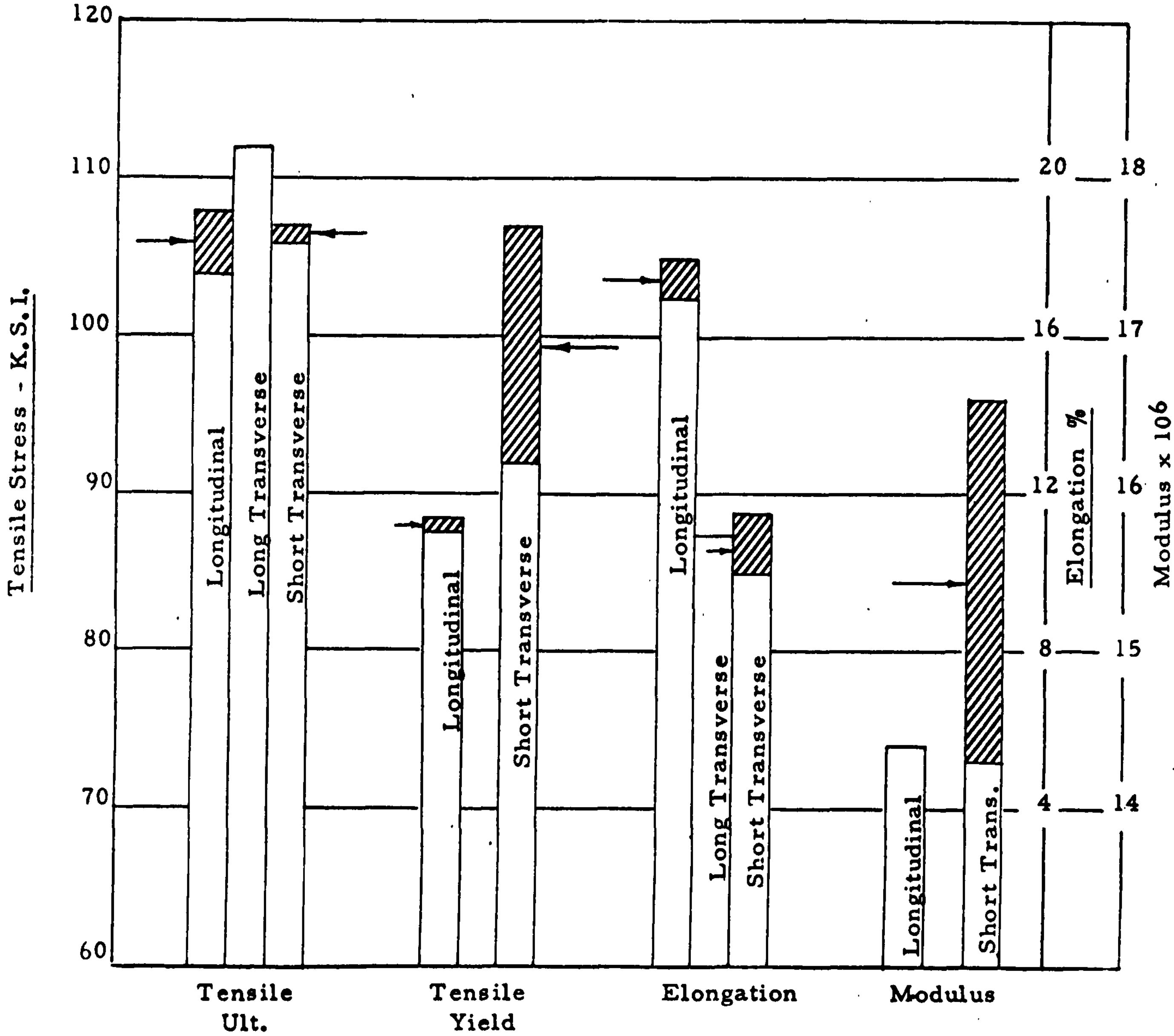
Legend - Shaded Area Indicates Range.
Arrow Indicates Average Values.

Summary of 600°F Tensile Values - Billet # 50077



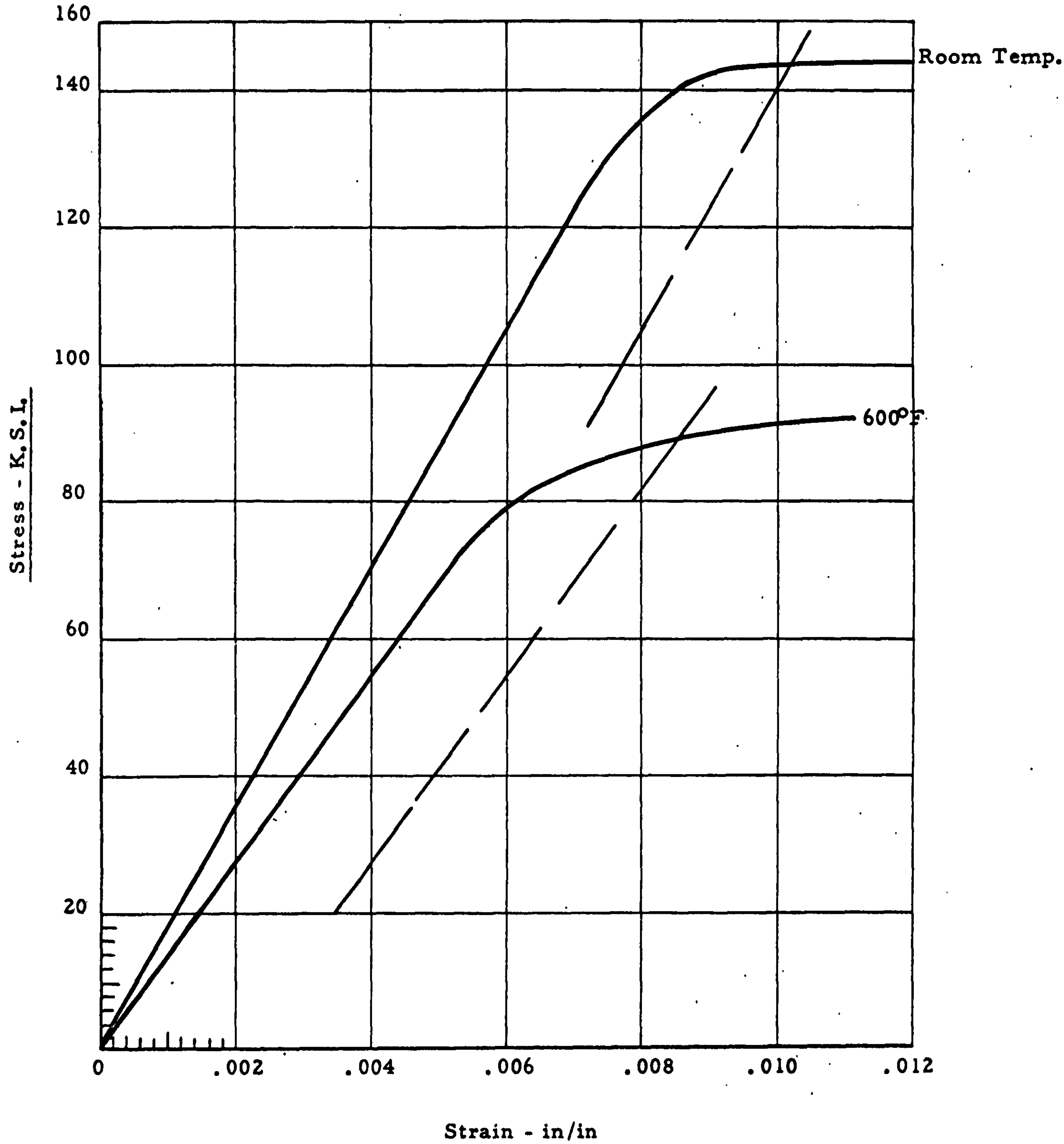
Legend - Shaded Area Indicates Range.
Arrow Indicates Average Values.

Summary of Room Temperature Tensile Values - Billet #51009

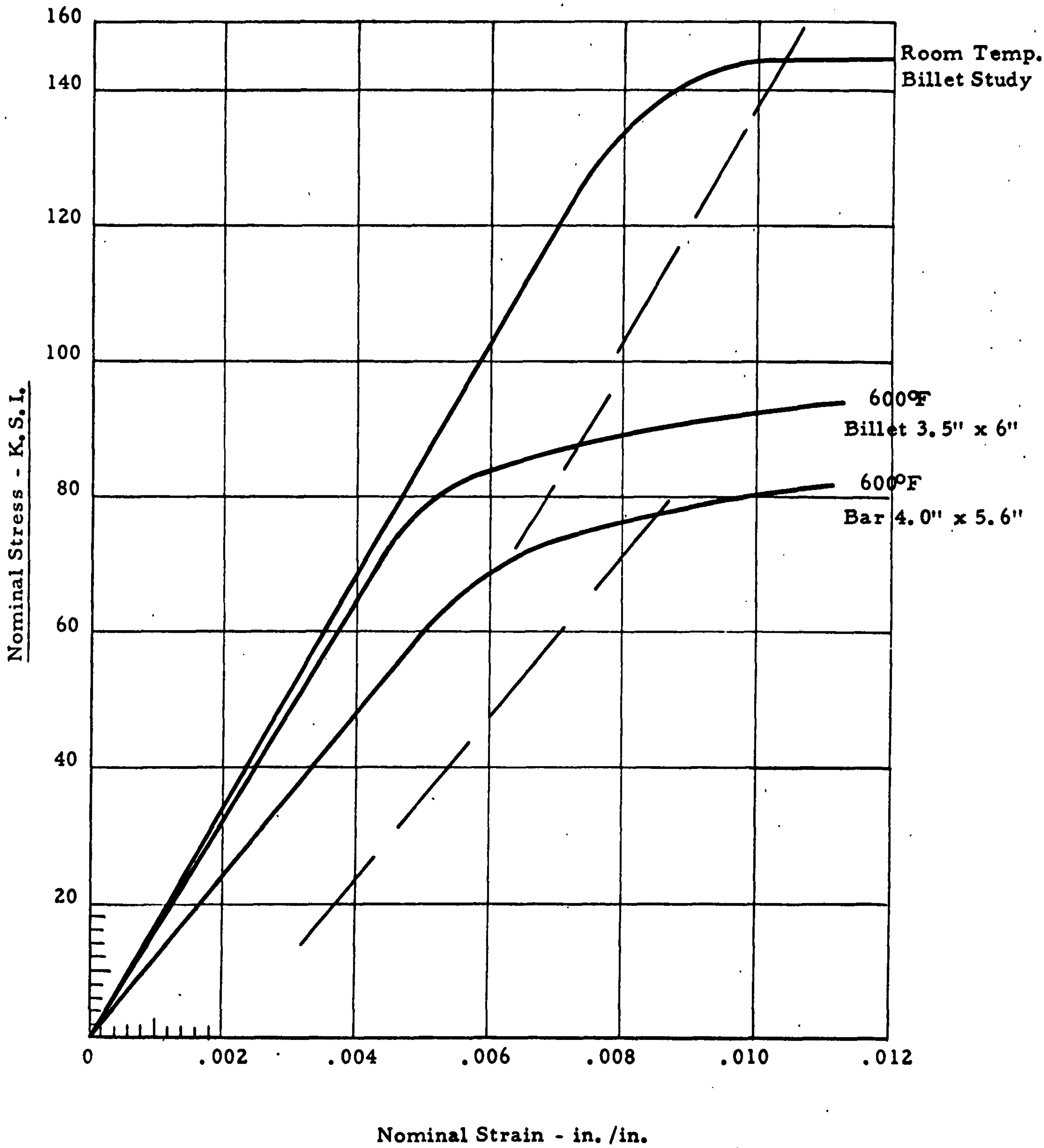


Legend - Shaded Area Indicates Range.
Arrow Indicates Average Values.

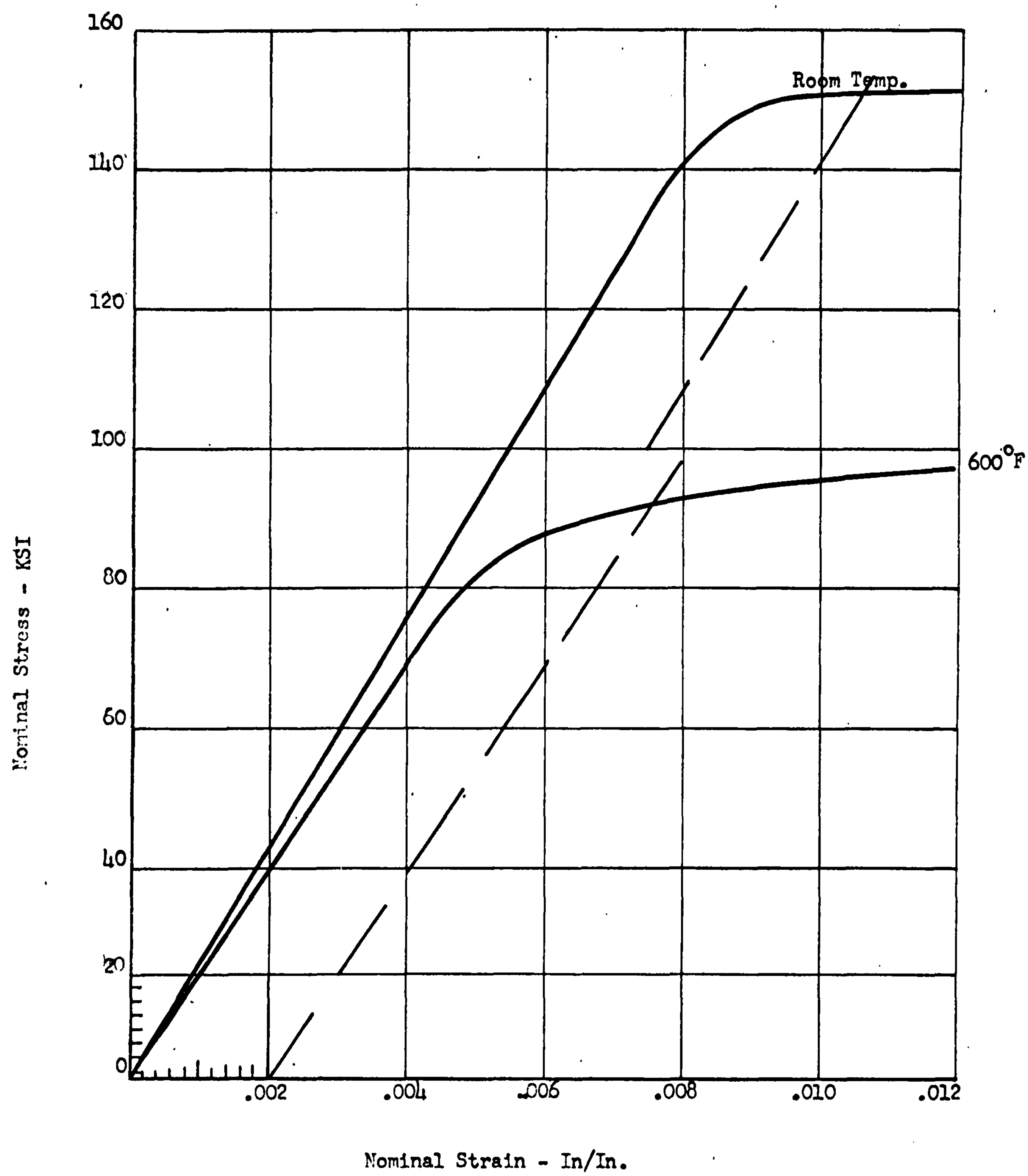
Summary of 600°F Tensile Values - Billet #51009



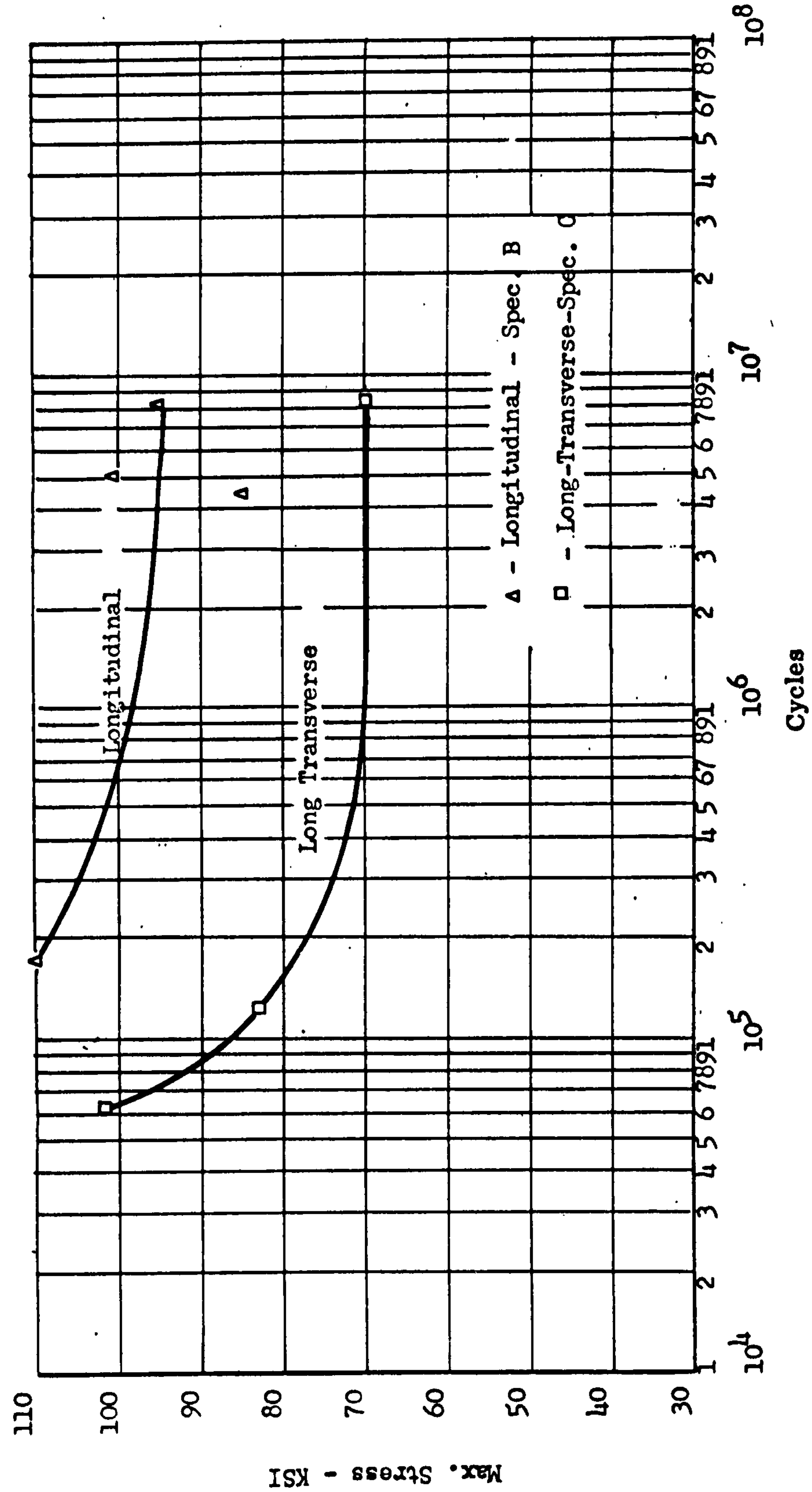
Typical Stress-Strain Curves for Longitudinal Specimens
at Room Temperature and 600°F - Billet # 51009



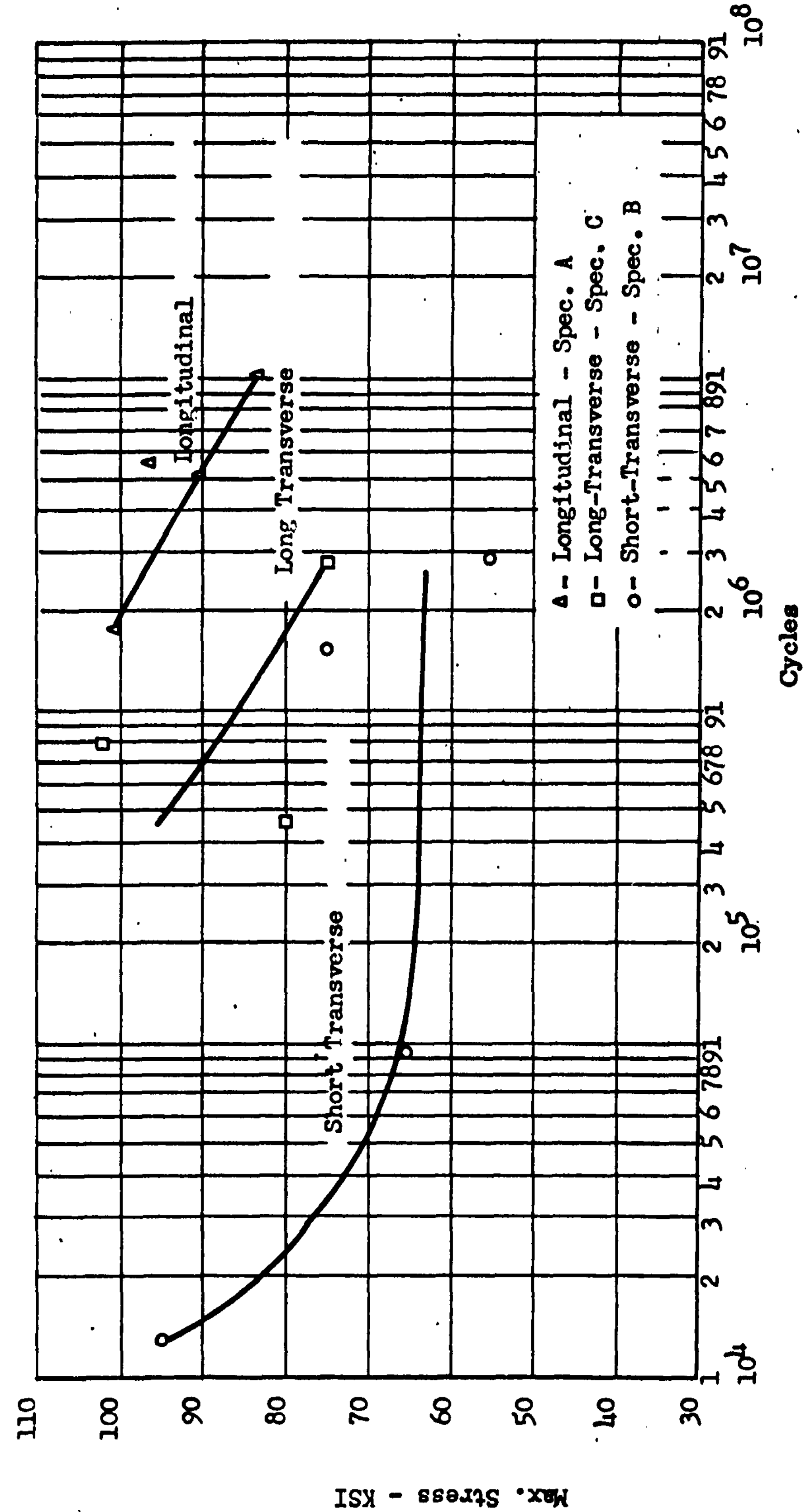
Typical Stress Strain Curves for Long Transverse Specimens at Room Temperature and 600°F



Typical Stress-Strain Curves for Short Transverse Specimens at Room Temperature and 600°F
Billet 51009

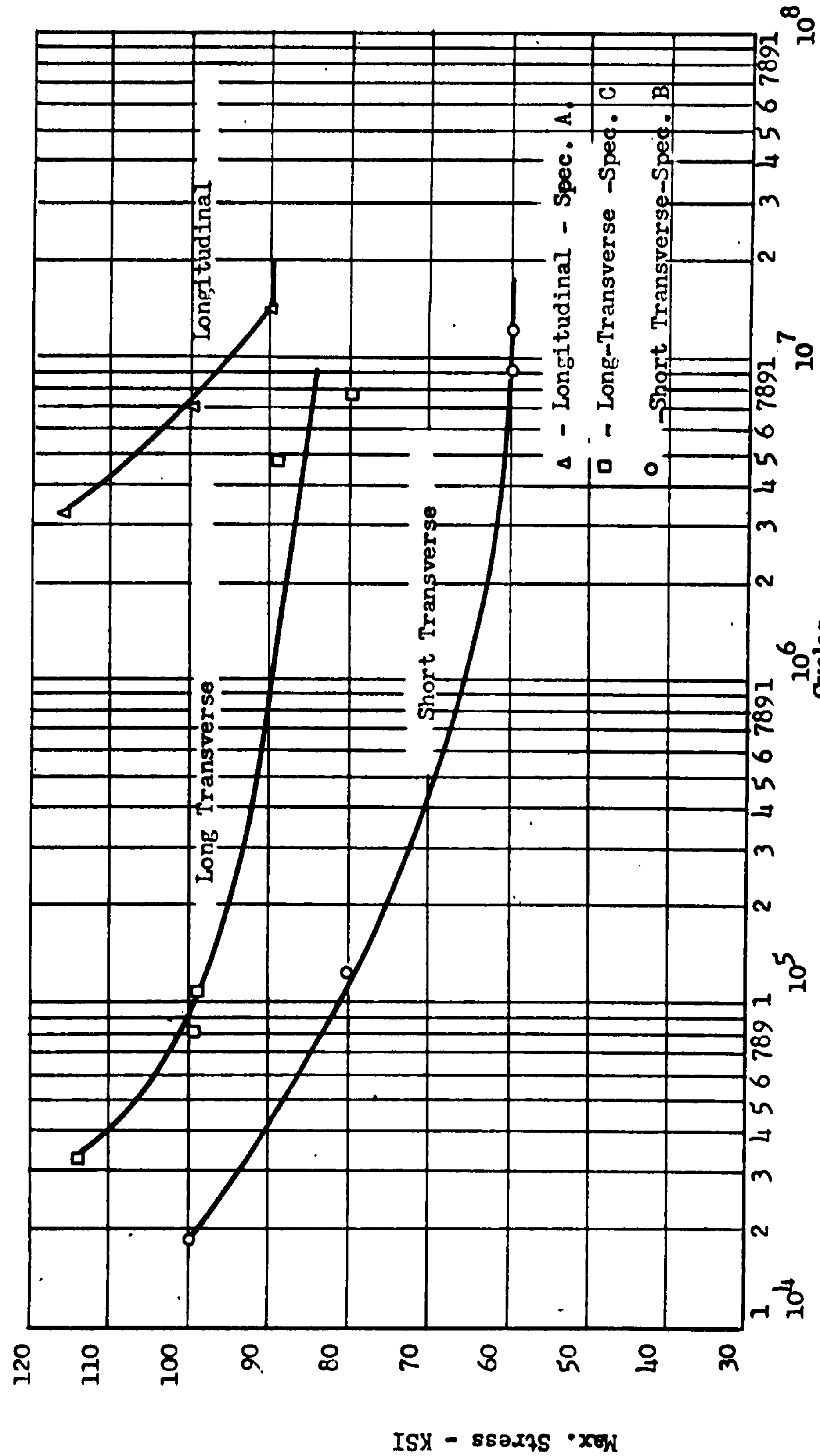


Room Temperature Fatigue Tests - Billet # 50077



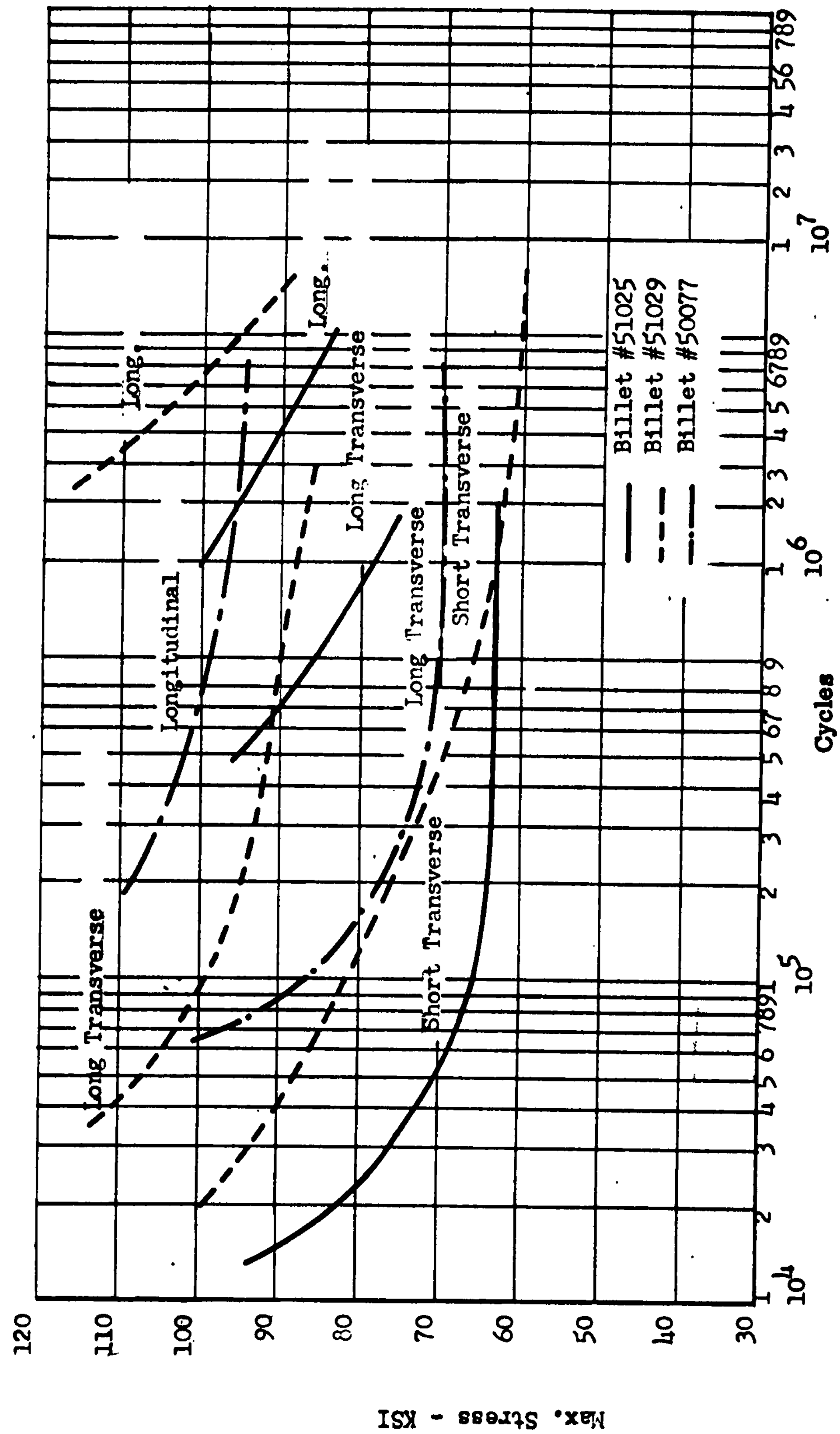
Room Temperature Fatigue Tests

Billet #51025



Room Temperature Fatigue Test

Billet #51029



Summary of Room Temperature Fatigue Tests

MECHANICAL PROPERTIES OF 5Al-2.5Sn TITANIUM

MATERIAL IDENTIFICATION (COML.)	MATERIAL STATUS
A110AT	Production
HEAT OR BATCH NUMBER	**FORM**
See Data	Sheet
PROCESSING CONDITION	
Mill Annealed	
OBJECT OF TEST	**RAC DATA REF.**
Determine Spotweld Characteristics of Sheet .025"-.072" Thick	ERM-13 dated July 23, 1956
SPECIMEN TYPE	
See Pages 17 and 18	

TEST METHOD:

The tables following present the results of an evaluation of spotweld characteristics of A110AT titanium alloy sheet ranging in thickness from .025" to .078". Shown are data on shear strength at room temperature and elevated temperatures up to 1000°F, tension ("pull-out") strength at room temperature, and fatigue tests in both shear and tension at room temperatures.

TEST PROCEDURE:

In order to insure consistency among the specimens tested, the same preparation procedure was followed for all specimens and was as follows:

1. RAC Welder No. 55 Sciaky PMCO-3ST, 3-phase frequency converter spotwelder was utilized throughout for all spotwelding tests.

2. Spotwelds were made on material of .025, .031, .040, .050, .062, and .078 inch in thickness.

3. A timing check was made of the welder prior to running any tests.

4. Welder was checked for consistency by welding 10 test specimens of half-hard stainless steel.

5. Settings used in regard to pressure and heat time were identical to those derived for stainless steel. Current was adjusted to secure the desired shear strength and penetration.

6. Tensile pull-out specimens ("U" sections) were welded at the same time as the tensile shear specimen.

7. Material was welded in the "as-received" condition (see page 4) with no chemical or mechanical cleaning except for hand wiping the metal surface.

Complete welding data is noted in the following chart.

Settings Utilized in Welding Titanium Alloy A110AT

Gage	Electrode Contour	PSI	Cycle	Heat Time	Heat Phase	Cool Time	No. of Impulses
.025-.025	5/16W-3R Flat	17-10 730 Lbs.	Constant	4	58%	1	2
.031-.031	5/16W-3R Flat	21-10 1720 Lbs.	Constant	4	60%	1	2
.040-.040	3/8W-3R Flat	28-10 1720 Lbs.	Constant	6	62%	1	2
.050-.050	3/8W-3R Flat	32-10 2080 Lbs.	Constant	6	66%	1	2
.062-.062	5/8W-3R Flat	37-10 2530 Lbs.	Constant	6	69%	1	2
.078-.078	5/8W-3R Flat	43-10 3070 Lbs.	Constant	8	63%	1	4

All specimens were then deburred.

The shear specimens were tested on a Baldwin-Emery SR-4 testing machine of 50,000 pounds capacity after allowing the specimens to soak at temperature for one-half hour. Ultimate load versus temperature data was recorded and plotted.

The oven used to reach and maintain temperatures was a portable two-piece unit which could be placed around the specimen and removed after testing. A chromel-Alumel thermocouple and potentiometer was used to measure temperature which was accurate to ±10°F.

Two holes were drilled in the ends of the tensile shear specimens selected for fatigue testing in order to facilitate mounting into a Sontag 10,000 pound SF-10U fatigue testing machine. The "U" section specimens were attached to an adjustable jig and the whole assembly was then mounted on a Sontag 2,000 pound SF-1U fatigue testing machine. The adjustable jig was designed to insure a tight fit-up between the specimen and jig at all times during testing. This tended to prevent scattered results due to excessive vibration during testing. The min/max. ratio used for all fatigue tests was 0.1.

The photograph on page 36 (250X) illustrates the as-cast weld structure of titanium alloy A110AT. No voids were noted in the structure. However, there was some difference in appearance of the heat-affected zone of the base metal. This may account for the slight scatter found in the test results.

TITANIUM ALLOY A110AT

Material Thickness	Heat No.	Average Tensile Pullout - Lbs. Set 1	Set 2	Average Tensile Shear Lbs. Set 1	Set 2	Set 3	Ratio Tensile Pullout to Tensile Shear Set 1	Set 2
.025-.025	D-41209	270	255	1648	1598	1374	.164	.159
.031-.031	D-40225	372	350	2028	2037	1940	.183	.172
.040-.040	D-40330	460	485	2911	2930	3042	.158	.165
.050-.050	D-40225	560	605	3586	3568	3565	.156	.170
.062-.062	D-43157	685	745	4770	5791	4806	.143	.128
.078-.078	D-40225	968	1135	6354	6123	6200	.152	.186

NOTES:

Set 1. First series of test results from RAC Shop Processes Section

Set 2. Second series of test results from RAC Shop Processes Section

Set 3. Results from RAC Engineering Research Section

AS-RECEIVED MATERIAL CONDITION A110AT TITANIUM

Heat No.	Grade and Condition	Size	U.T.S. psi	Y.S. ksi	Elong. %	Bend	Less than	Chemistry C	N	MN	Al	Sn
D-41209	A110AT Annealed	.025	123.9	119.0	13.8	4.0T		.1%	.02		6.3	2.3
D-40225	"	.032	130.3	120.0	15.5	4.0T		.1%	.02		5.6	2.1
D-40220	"	.040	136.2	122.9	14.0	4.0T		.1%	.02		4.4	2.5
D-40225	"	.050	129.7	121.3	15.2	4.0T		.1%	.02		6.0	2.1
D-43157	"	.064	143.1	136.6	14.1	4.0T		.1%	.03		6.3	2.0

ELEVATED TEMPERATURE SHEAR DATA

.025" TITANIUM

Temperature °F	Ultimate Load Lbs.	Average
Room Temp.	1500	
Room Temp.	1135	
Room Temp.	1510	
Room Temp.	1350	
Room Temp.	1580	
Room Temp.	1460	
Room Temp.	1525	
Room Temp.	1240	
Room Temp.	1310	
Room Temp.	1125	
		1374
100	1260	
100	1580	
100	1530	
		1457
150	1220	
150	1430	
150	1510	
		1387
200	1170	
200	1430	
200	1500	
		1367
250	1200	
250	1390	
250	1400	
		1330
300	1140	
300	1300	
300	1410	
		1283
350	1200	
350	1370	
350	1200	
		1257
400	1180	
400	1290	
400	1250	
		1240
450	1260	
450	1320	
450	1090	
		1223

Temperature °F	Ultimate Load Lbs.	Average
500	1220	
500	1200	
500	1100	
500	1140	
		1187
550	1180	
550	1040	
550	1170	
		1130
600	1200	
600	1120	
600	1110	
		1193
650	1140	
650	1090	
650	1090	
		1090
700	1080	
700	1090	
700	1000	
		1057
750	1000	
750	1030	
750	1160	
		1063
800	990	
800	1120	
800	1010	
		1040
850	1035	
850	940	
850	1010	
		995
900	1000	
900	950	
900	1000	
		983
950	1000	
950	960	
950	950	
		970
1000	1000	
1000	940	
1000	880	940

ELEVATED TEMPERATURE SHEAR DATA

.032" TITANIUM

Temperature °F	Ultimate Load lbs.	Average	Temperature °F	Ultimate Load lbs.	Average
Room Temp.	1920		500	1600	
Room Temp.	1900		500	1620	
Room Temp.	2000		500	1530	
Room Temp.	1940		500	1640	
		1940			1598
100	1960		550	1580	
100	1935		550	1610	
100	1870		550	1680	
100	1980				1623
		1936	600	1620	
150	1945		600	1460	
150	2050		600	1400	
150	1950				1493
150	1840		650	1620	
		1946	650	1460	
200	1935		650	1600	
200	1860				1560
200	1930		700	1570	
200	1940		700	1430	
		1916	700	1470	
250	1830				1490
250	1900		750	1550	
250	1920		750	1380	
250	1880		750	1350	
		1883			1427
300	1775		800	1530	
300	1770		800	1450	
300	1730		800	1350	
300	1840				1443
		1779	850	1520	
350	1750		850	1380	
350	1765		850	1390	
350	1630				1430
350	1750		900	1500	
		1716	900	1390	
400	1740		900	1400	
400	1600				1430
400	1730		950	1460	
400	1760		950	1440	
		1708	950	1450	
450	1640				1450
450	1660		1000	1400	
450	1670		1000	1300	
450	1700		1000	1350	
		1668			1350

ELEVATED TEMPERATURE SHEAR DATA

.040" TITANIUM

Temperature °F	Ultimate Load Lbs.	Average
Room Temp.	3040	
Room Temp.	3140	
Room Temp.	3040	
Room Temp.	2950	
Room Temp.	3040	
		3042
100	3040	
100	3100	
100	3000	
100	2900	
100	3060	
		3024
150	3100	
150	3200	
150	3200	
150	3140	
150	3200	
		3172
200	2900	
200	3140	
200	3140	
200	3290	
200	3160	
		3126
250	2840	
250	2960	
250	2980	
250	3050	
250	3030	
		2972
300	2900	
300	2740	
300	2940	
300	2940	
300	2960	
		2896

ELEVATED TEMPERATURE SHEAR DATA

.040" TITANIUM

Temperature °F	Ultimate Load Lbs.	Average
350	2745	
350	2800	
350	2880	
350	3000	
350	2800	
		2845
400	2700	
400	2640	
400	2920	
400	2530	
400	2770	
		2712
450	2620	
450	2640	
450	2940	
450	2700	
450	2640	
		2708
500	2360	
500	2320	
500	2900	
500	2440	
500	2590	
		2512
550	2300	
550	2310	
550	2800	
550	2500	
550	2520	
550	2540	
		2495
600	2300	
600	2220	
600	2540	
600	2620	
600	2380	
600	2440	
		2417
650	2260	
650	2240	
650	2300	
650	2400	
650	2370	
650	2210	
		2297

Temperature °F	Ultimate Load Lbs.	Average
700	2140	
700	2200	
700	2200	
700	2220	
700	2250	
700	2340	
		2225
750	2210	
750	2200	
750	2100	
750	2180	
750	2140	
750	2140	
		2162
800	1940	
800	2000	
800	2130	
800	2100	
800	2180	
800	2040	
		2065
850	1900	
850	1960	
850	2100	
850	2040	
850	1950	
850	2120	
		2011
900	1955	
900	1965	
900	2000	
900	2050	
900	1940	
900	1910	
		1970
950	1860	
950	1870	
950	1920	
950	2000	
950	1900	
950	2000	
		1925

ELEVATED TEMPERATURE SHEAR DATA

.040" TITANIUM (cont'd)

Temperature °F	Ultimate Load Lbs.	Average
1000	1820	
1000	1900	
1000	1770	
1000	1800	
1000	1880	
1000	1630	
		1800

ELEVATED TEMPERATURE SHEAR DATA

.050"TITANIUM

Temperature °F	Ultimate Load lbs.	Average	Temperature °F	Ultimate Load lbs.	Average
Room Temp.	3500		450	3210	
Room Temp.	3680		450	3200	
Room Temp.	3620		450	3360	
Room Temp.	3460		450	3210	
		3565			3245
100	3315		500	3100	
100	3410		500	3110	
100	3600		500	3220	
100	3560		500	3160	
		3474			3148
150	3380		550	3155	
150	3740		550	3185	
150	3640		550	3110	
150	3390		550	2990	
		3538			3110
200	3440		600	3130	
200	3350		600	3140	
200	3560		600	2970	
200	3570		600	3200	
		3480			3135
250	3430		650	3060	
250	3165		650	3095	
250	3480		650	3080	
250	3380		650	2720	
		3336			2989
300	3420		700	3000	
300	3430		700	3025	
300	3310		700	2800	
300	3380		700	2860	
		3385			2921
350	3400		750	2940	
350	3410		750	2960	
350	3400		750	2850	
350	3200		750	2860	
		3352			2902
400	3340		800	2840	
400	3300		800	2800	
400	3240		800	2880	
400	3200		800	2740	
	3270				2795

ELEVATED TEMPERATURE SHEAR DATA

.050" TITANIUM (cont'd)

Temperature °F	Ultimate Load Lbs.	Average
850	2795	
850	2810	
850	2720	
850	2670	
		2749
900	2650	
900	2635	
900	2680	
900	2785	
		2690
950	2780	
950	2880	
950	2600	
950	2600	
		2715
1000	2600	
1000	2615	
1000	2920	
1000	2720	
		2714

ELEVATED TEMPERATURE SHEAR DATA

.062" TITANIUM

Temperature °F	Ultimate Load Lbs.	Average
Room Temp.	4920	
Room Temp.	4760	
Room Temp.	4700	
Room Temp.	4800	
Room Temp.	4860	
Room Temp.	4800	
Room Temp.	4800	
		4806
100	4600	
100	4480	
100	4440	
100	4800	
100	4680	
100	4680	
		4613
150	4680	
150	4500	
		4590
200	4780	
200	4700	
		4740
250	4580	
250	4570	
		4575
300	4380	
300	4350	
		4365
350	4200	
350	4120	
		4160
400	4060	
400	4040	
		4050
450	4000	
450	3980	
		3990
500	3900	
500	4000	
		3905
550	3760	
550	3760	
		3760
600	3810	
600	3660	
		3735

Temperature °F	Ultimate Load Lbs.	Average
650	3800	
650	3730	
		3765
700	3560	
700	3400	
		3480
750	3540	
750	3400	
		3470
800	3470	
800	3340	
		3405
850	3400	
850	3320	
		3360
900	3290	
900	3300	
		3295
950	3300	
950	3210	
		3260
1000	3360	
1000	3100	
		3230

ELEVATED TEMPERATURE SHEAR DATA

.078" TITANIUM

Temperature °F	Ultimate Load Lbs.	Average
150	6200	6200
200	6120	
200	6290	6205
250	6340	
250	6300	6320
300	5940	
300	5825	5883
350	6100	
350	6000	6050
400	5600	
400	5740	5670
450	5620	
450	5660	5640
500	5400	
500	5220	5310
550	5440	
550	5360	5400
600	5220	
600	5000	5110
650	4850	
650	4900	4875
700	4730	
700	4700	4715
750	4830	
750	4900	4865
800	4800	
800	4500	4650
850	4500	
850	4640	4570

Temperature °F	Ultimate Load Lbs.	Average
900	4500	
900	4740	4620
950	4560	
950	4340	4450
1000	3840	
1000	3400	3620

PULL-OUT FATIGUE TESTS

.025" TITANIUM

P_{max} = 255 %P_{max}	Load	Cycles
5	12.75	8,024,000 (no fracture)
10	25.5	464,000
15	38.25	94,000
30	76.5	43,000
50	127.5	4,000
70	168.5	1,000
90	229.5	0

.032" TITANIUM

P_{max} = 350 %P_{max}	Load	Cycles
15	52.5	2,121,000 (no fracture)
30	105.0	82,000
50	175.0	10,000
70	245.0	1,000
90	315,0	0

.040" TITANIUM

P_{max} = 485 %P_{max}	Load	Cycles
15	72.75	2,000,000 (no fracture)
30	145.5	96,000
50	242.5	4,000
70	339.5	1,000
90	436.5	0

PULL-OUT FATIGUE TESTS

.050" TITANIUM

$P_{max} = 605$

$\%P_{max}$	Load	Cycles
15	90.75	2,040,000(no fracture)
30	181.5	215,000
50	302.5	19,000
70	423.5	4,000
90	544.5	0

.062" TITANIUM

$P_{max} = 745$

$\%P_{max}$	Load	Cycles
30	223.5	2,098,000 (no fracture)
50	372.5	19,000
70	521.5	5,000
90	670.5	2,000

.078" TITANIUM

$P_{max} = 1135$

$\%P_{max}$	Load	Cycles
30	340.5	1,947,000
50	567.5	38,000
70	794.5	10,000
90	1021.5	0

TENSILE SHEAR FATIGUE TESTS

.025" TITANIUM

P_{max} = 1598

%P_{max}	Load	Cycles
10	159.8	413,000
15	239.7	23,000
30	479.4	4,000
50	799.0	1,000
70	1118.6	1,000
90	1438.2	0

.032" TITANIUM

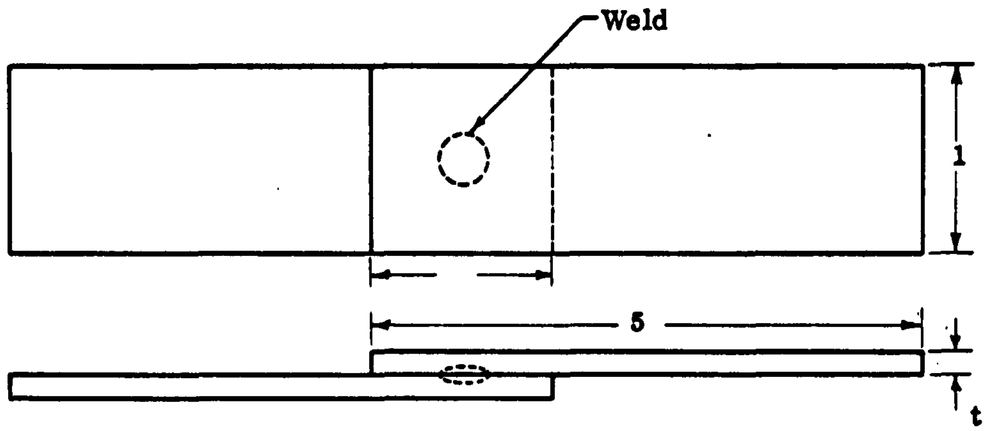
P_{max} = 2037

%P_{max}	Load	Cycles
10	203.7	412,000
15	305.55	12,000
30	611.1	4,000
50	1018.5	2,000
70	1425.9	1,000
90	1833.3	0

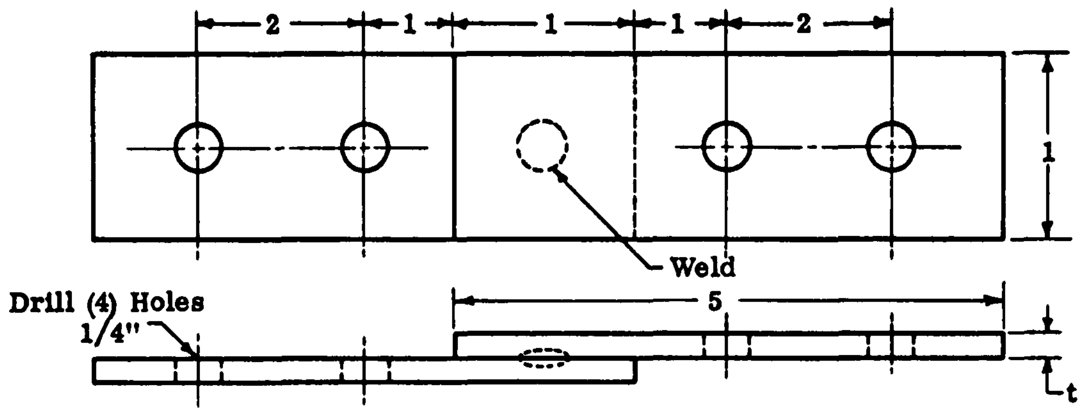
.040" TITANIUM

P_{max} = 2930

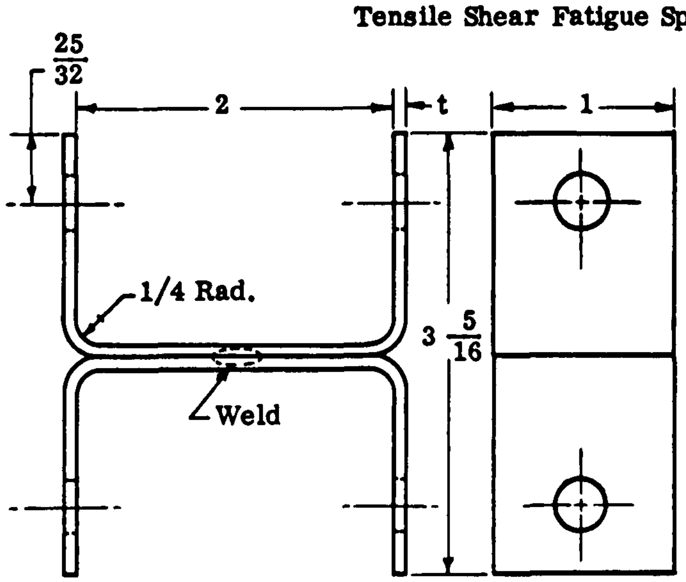
%P_{max}	Load	Cycles
10	439.5	183,000
15	293.0	38,000
30	879.0	7,000
50	1465.0	2,000
70	2051.0	2,000
90	2637.0	0



Tensile Shear Specimen



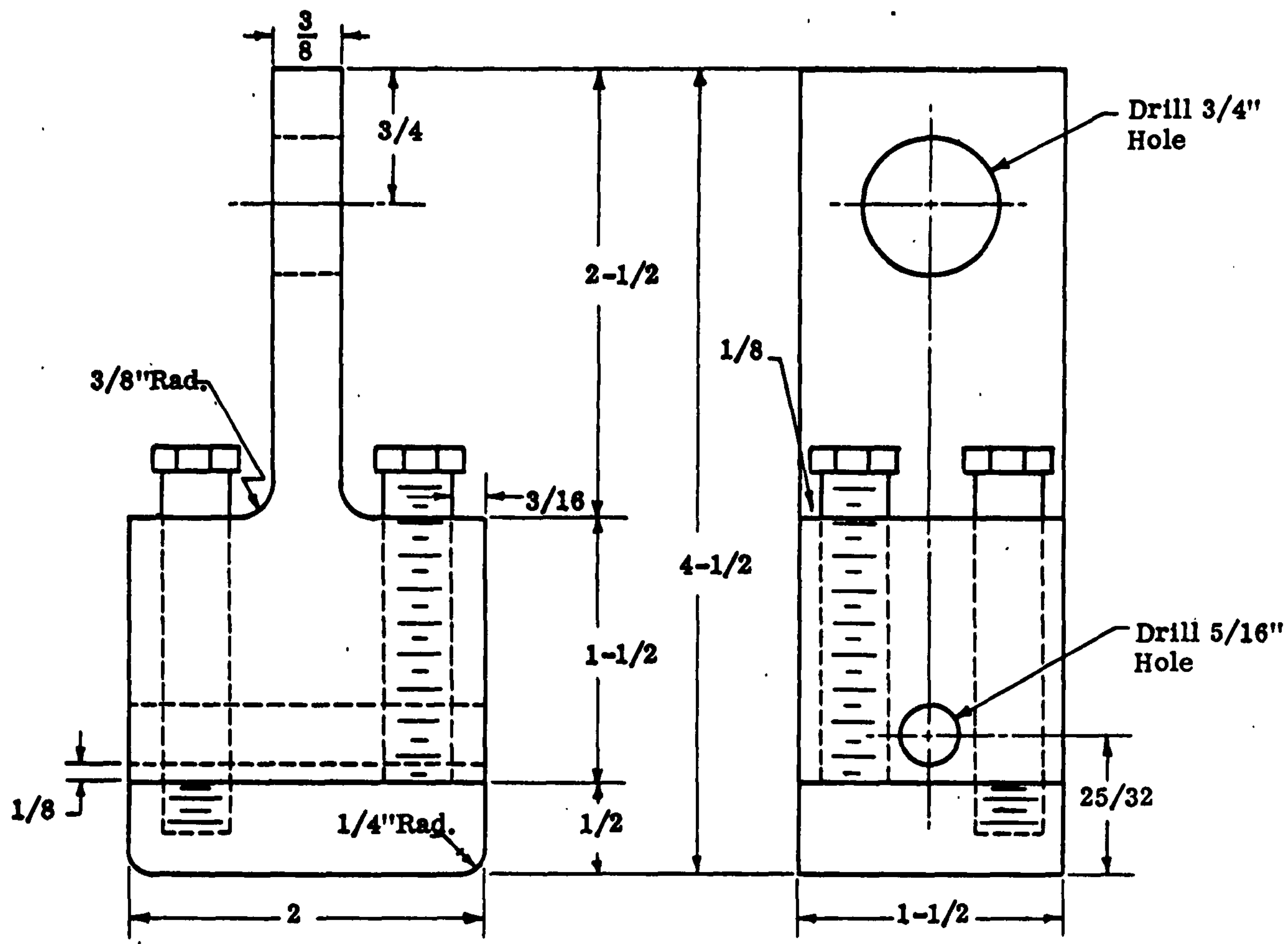
Tensile Shear Fatigue Specimen



U-Type Tensile Pullout and Fatigue Specimen

NOTES:

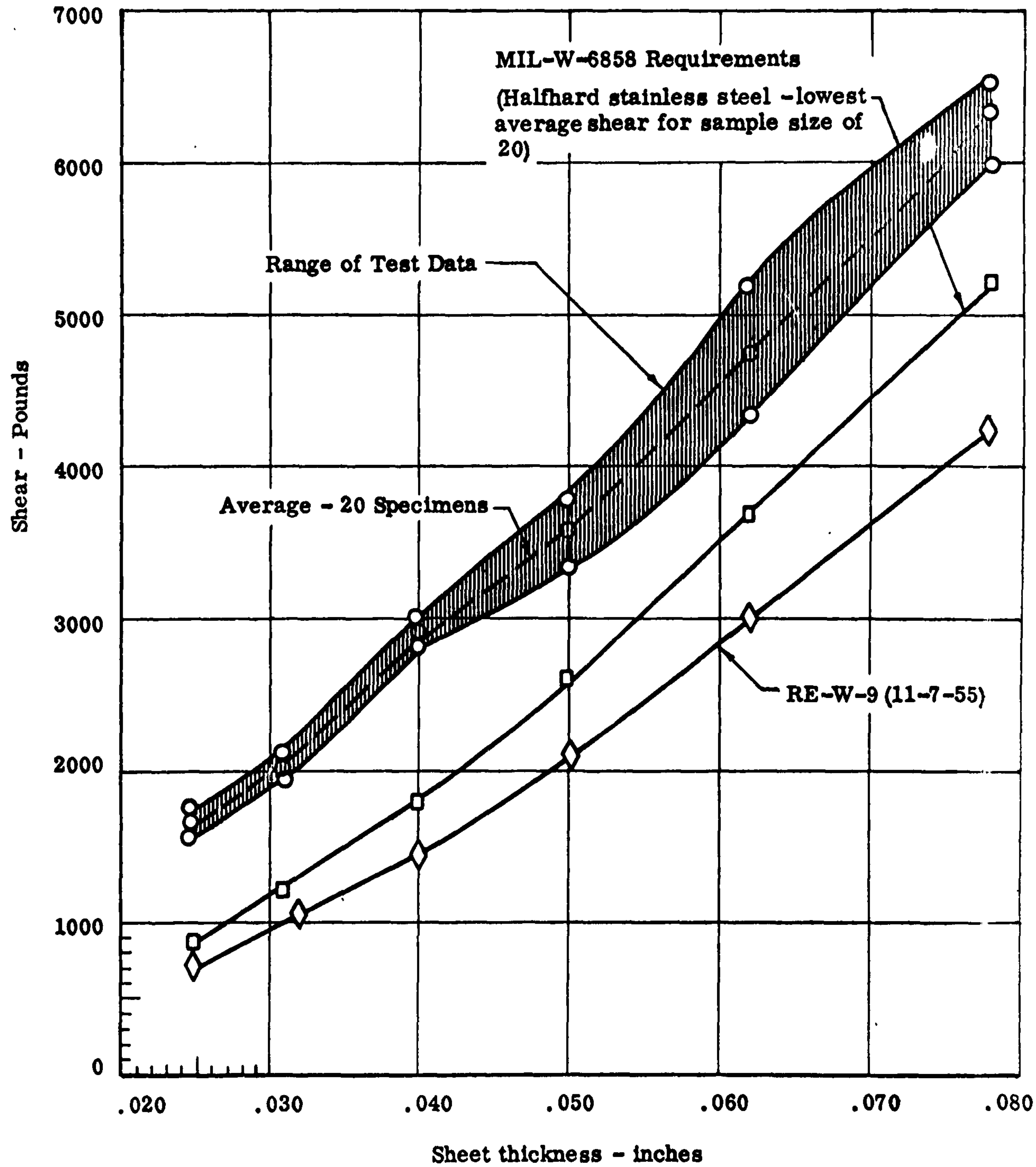
t = .025"
.031"
.040"
.050"
.064"
.078"



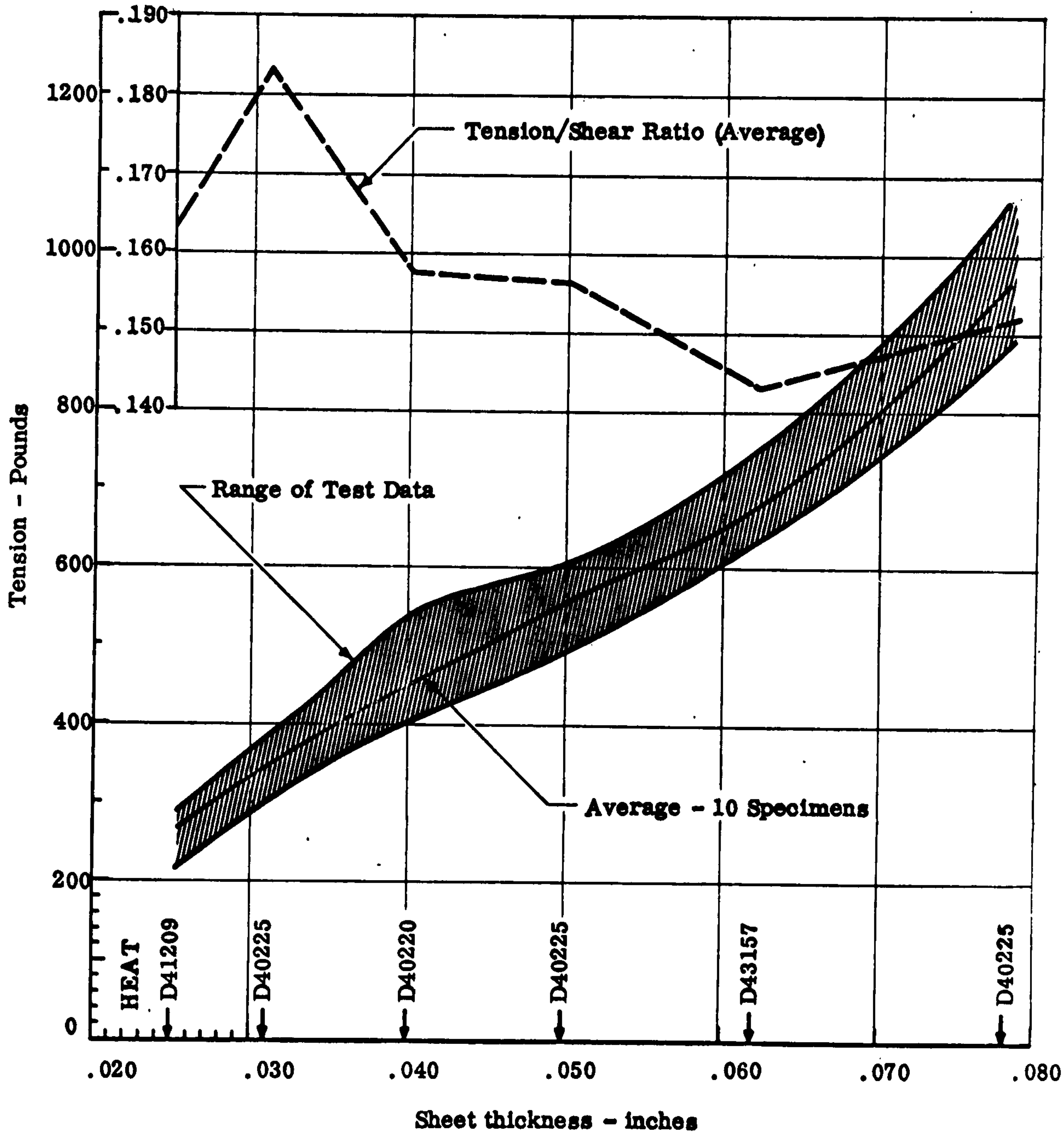
NOTES:

1. Four 3/8-16 NC bolts are used to hold assembly together.
2. Bottom of jig opens 1/4" giving over-all length of 4-3/4".
3. Material = 4340

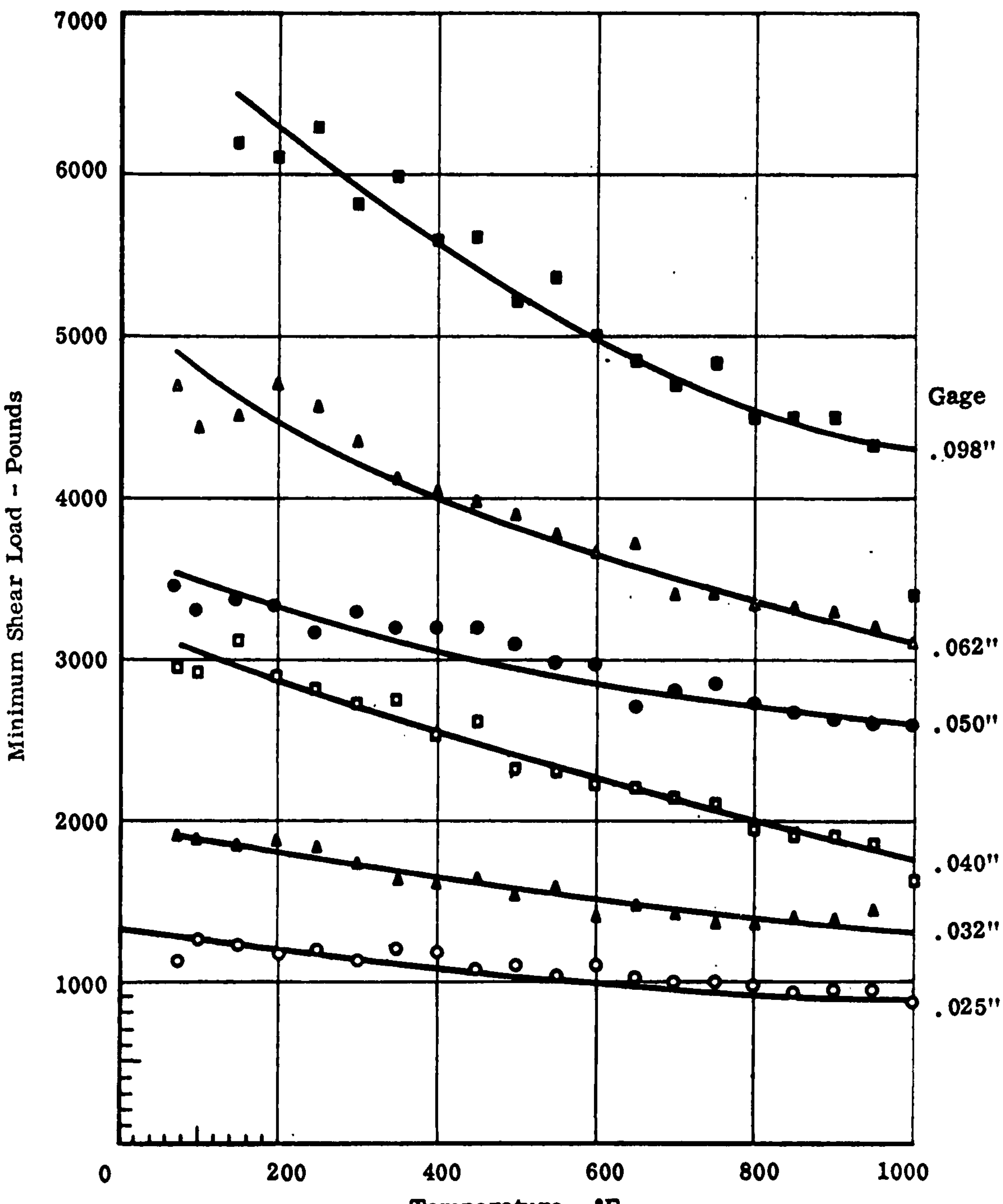
Adjustable U-Section Fatigue Specimen Jig



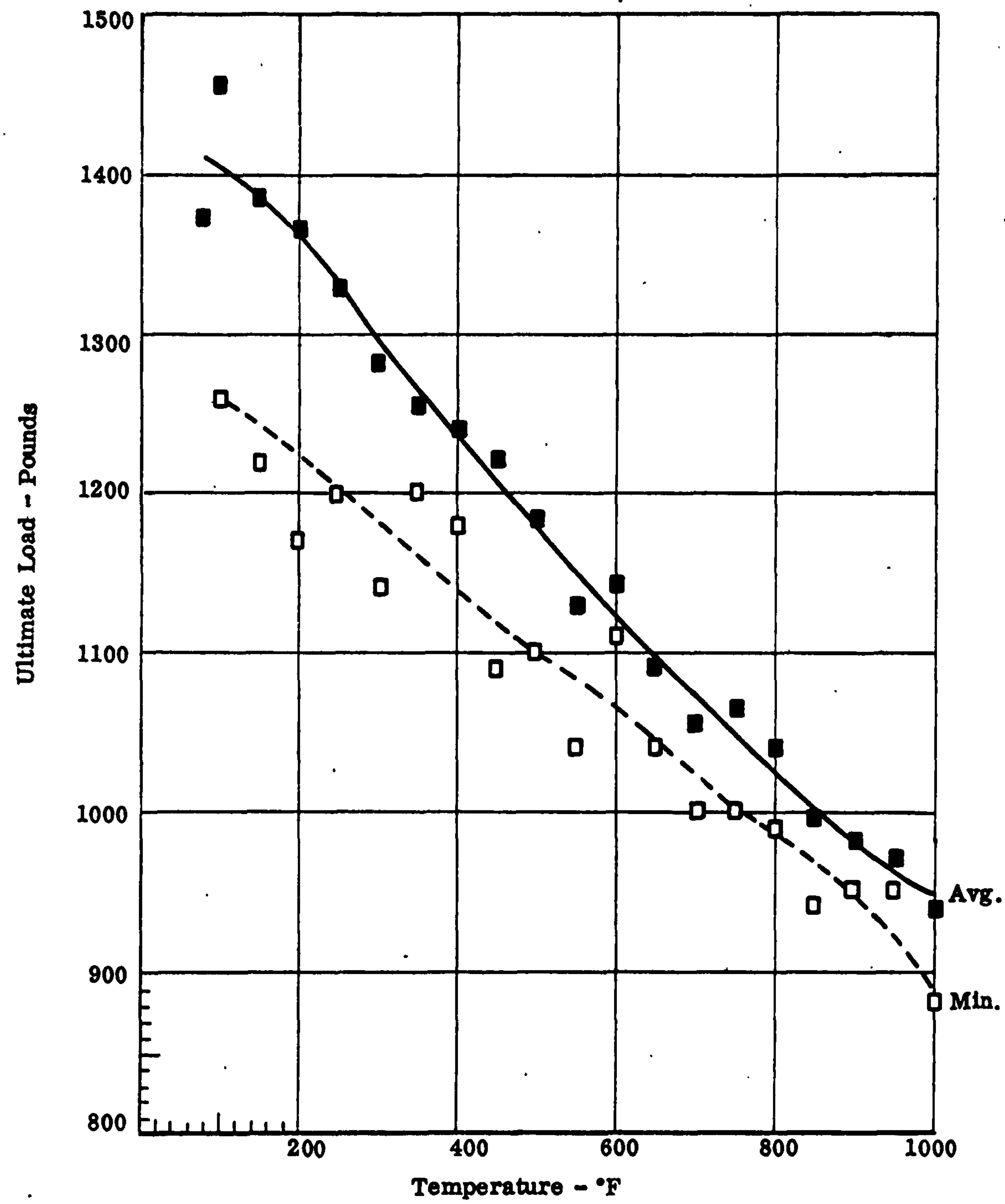
A110AT Titanium Alloy Spot Welding Tests - Shear Results



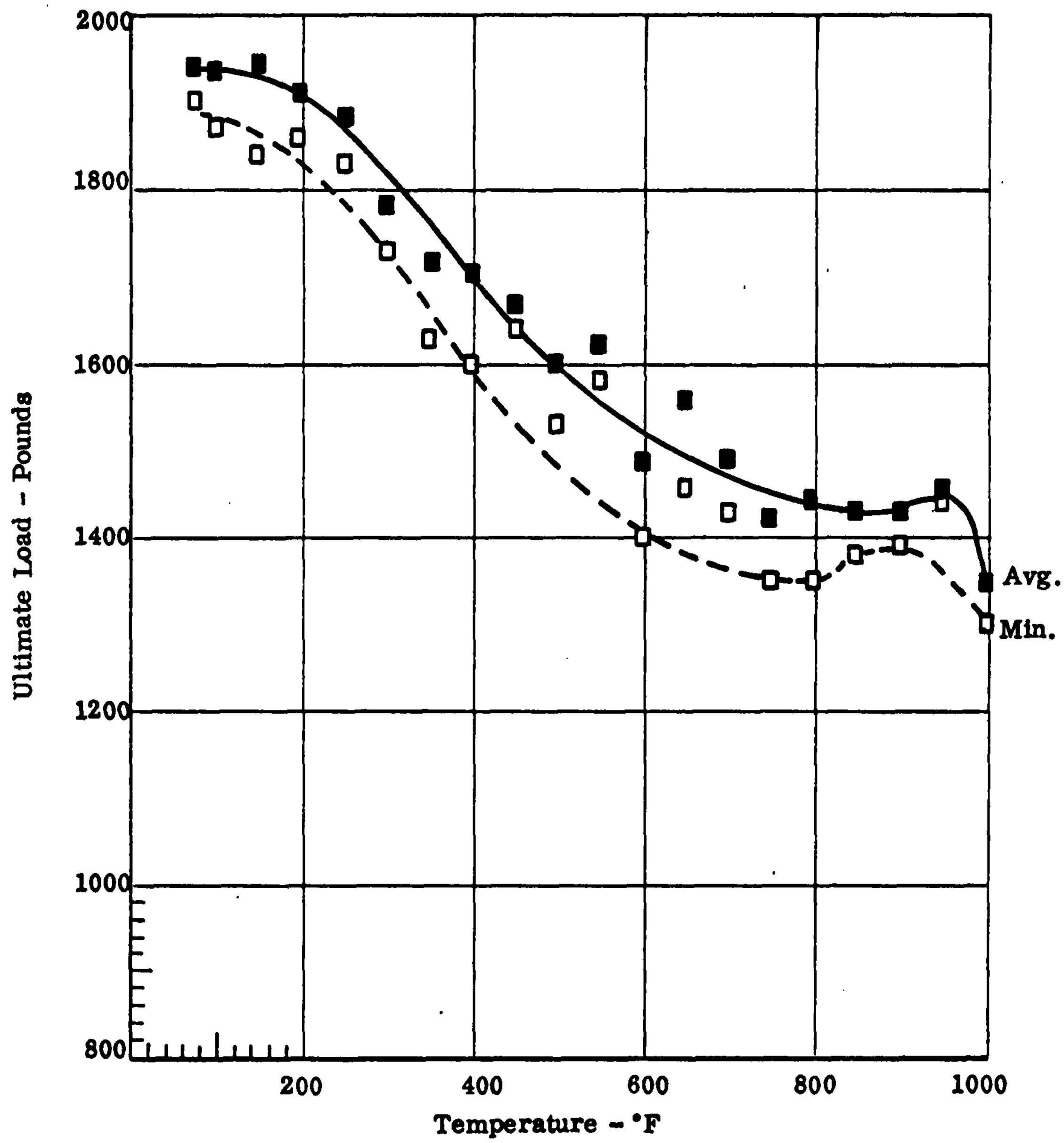
A110AT Titanium Alloy
Spot Welding Tests
Tension Results



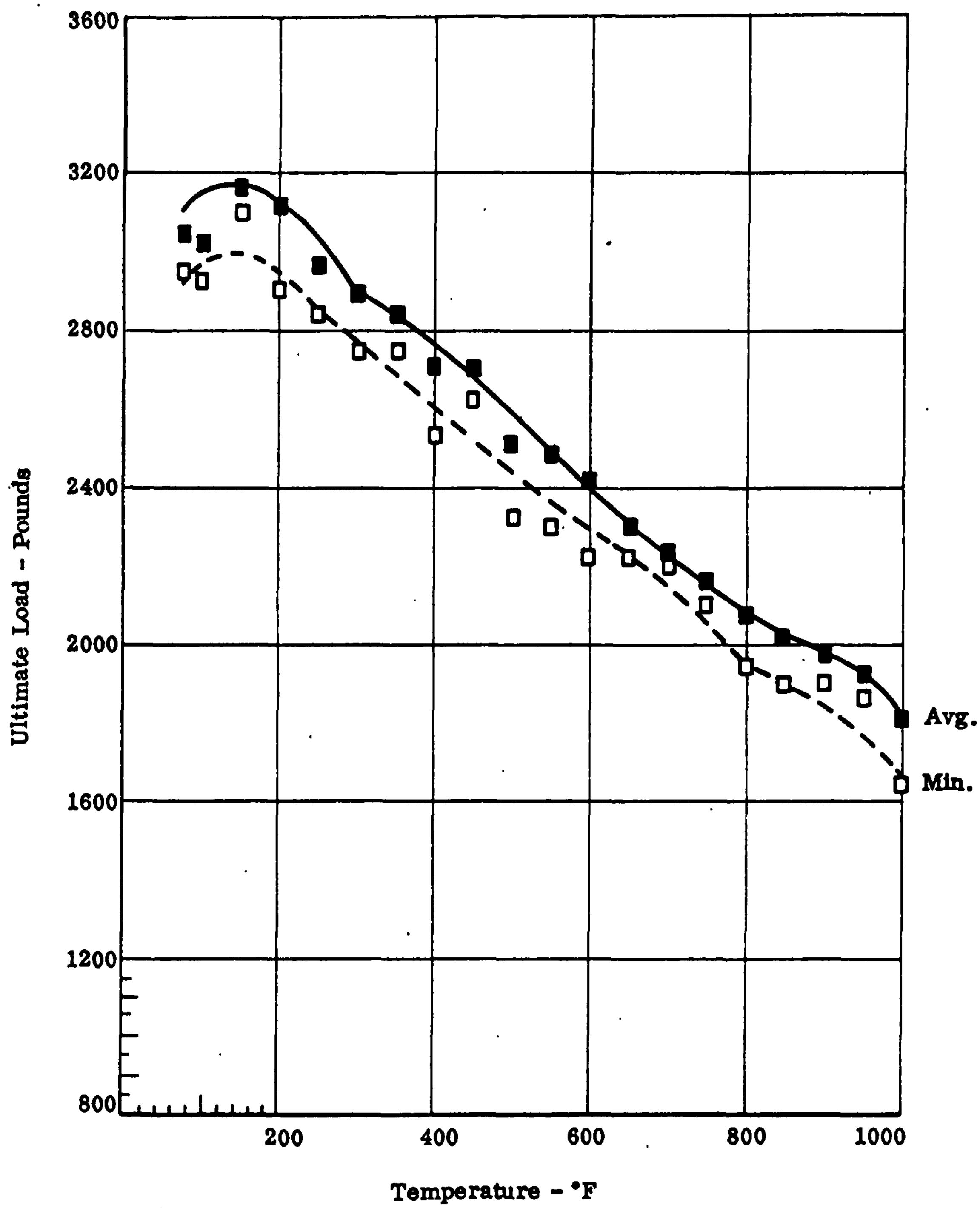
Elevated Temperature Shear Properties of Titanium Alloy A110AT Spot Welds



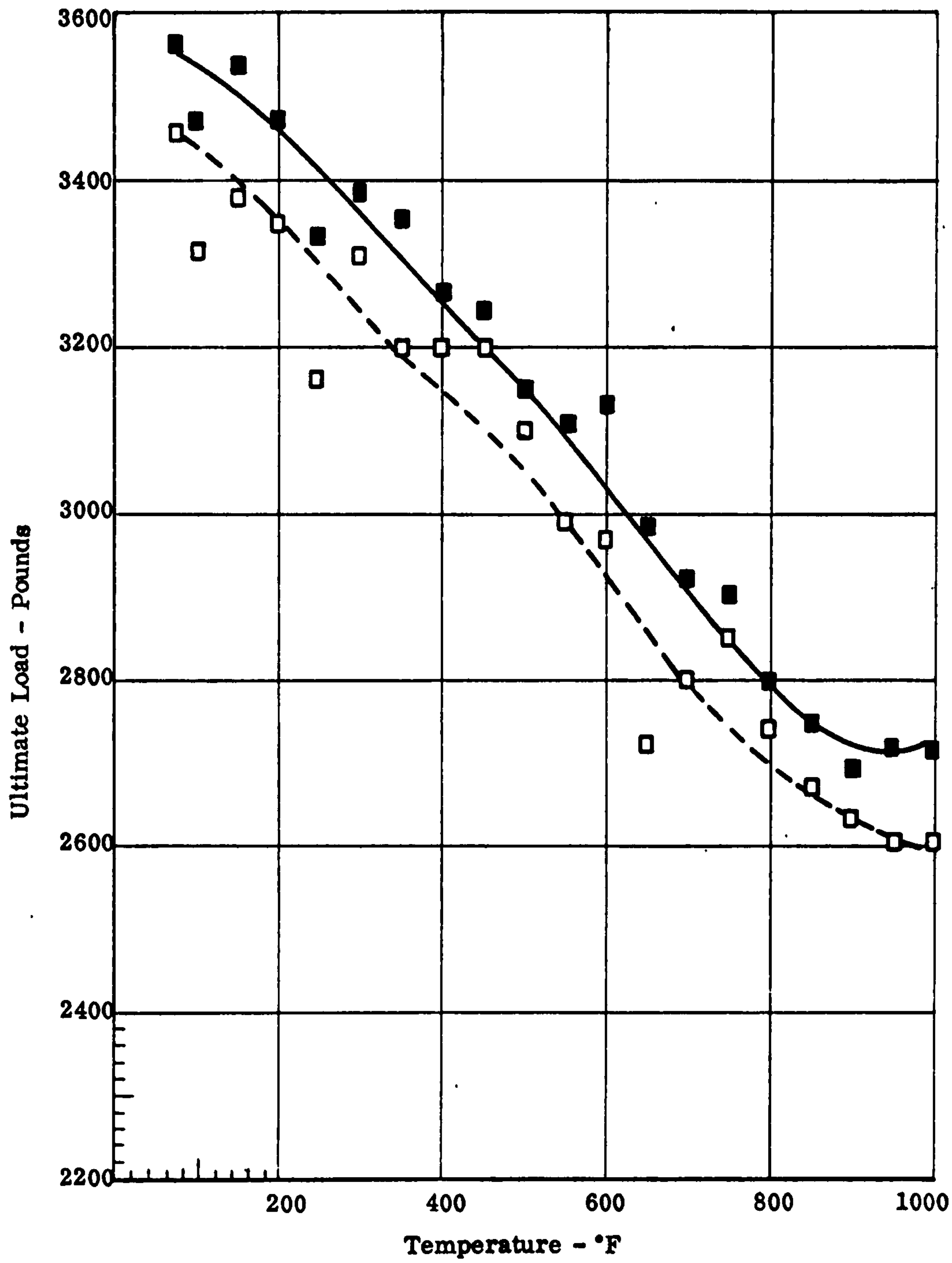
Load vs Temperature Properties - .025 Inch Spot Welded Sheet



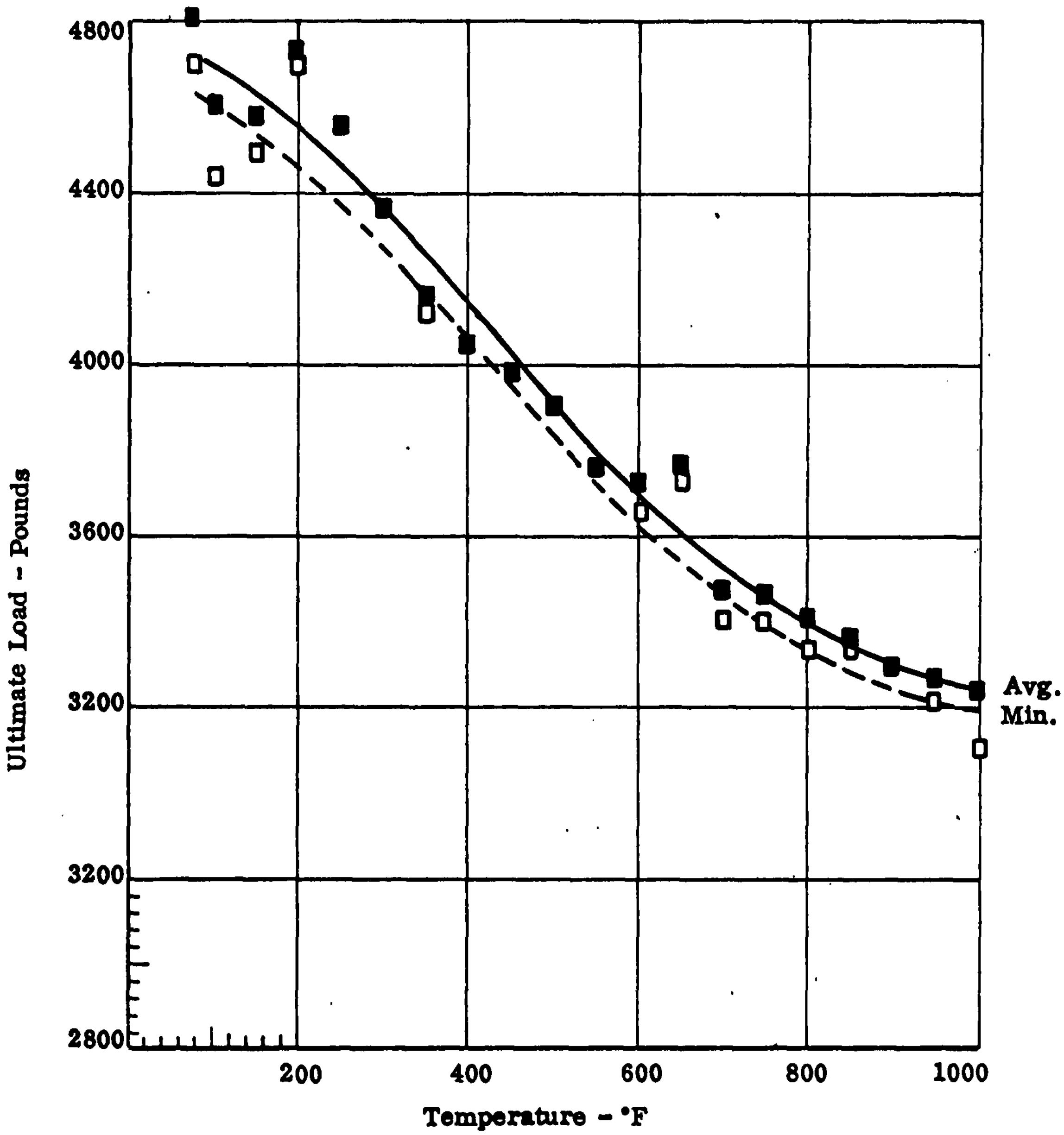
Load vs Temperature Properties - .032 Inch Spot Welded Sheet



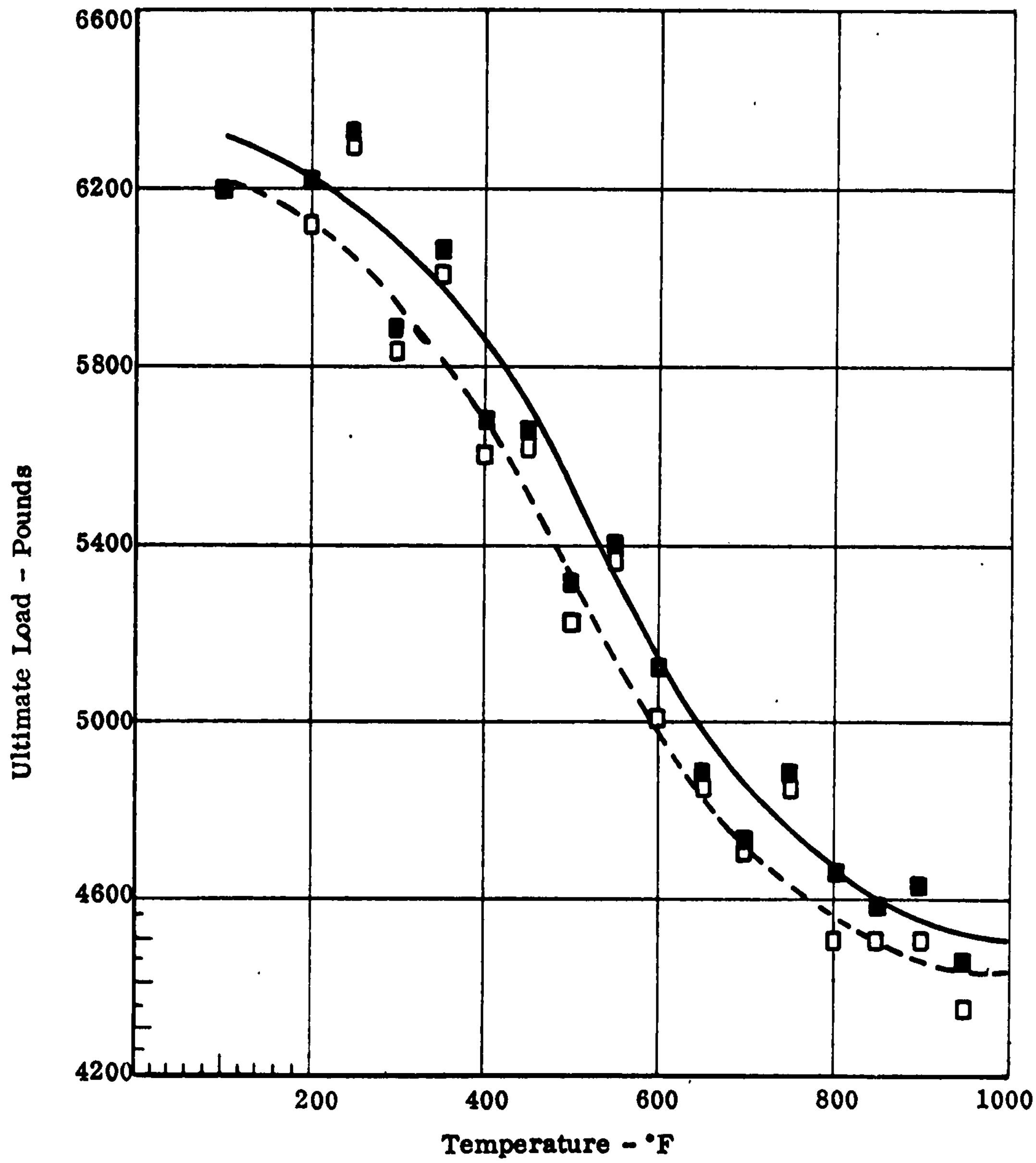
Load vs Temperature Properties - .040 Inch Spot Welded Sheet



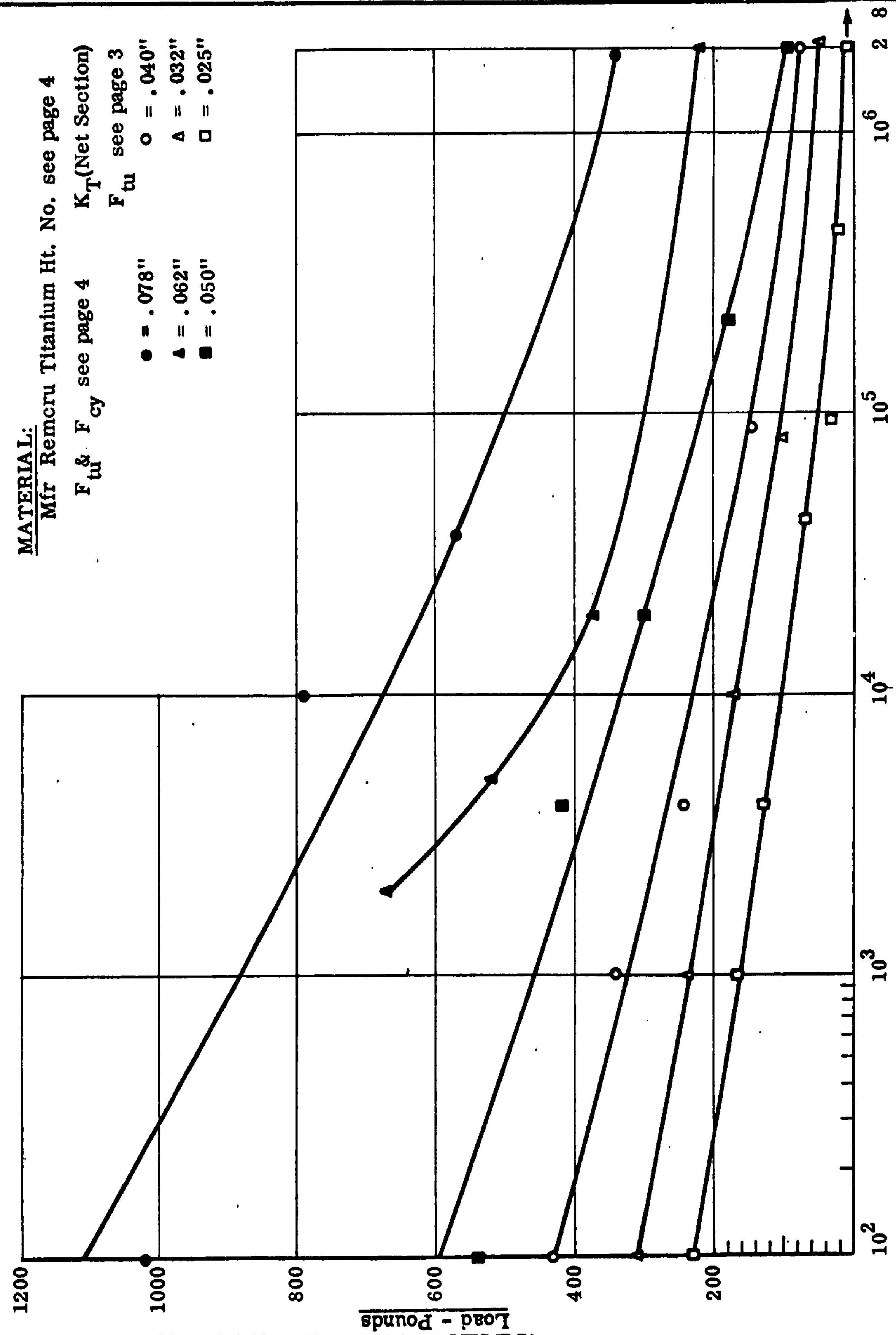
Load vs Temperature Properties - .050 Inch Spot Welded Sheet



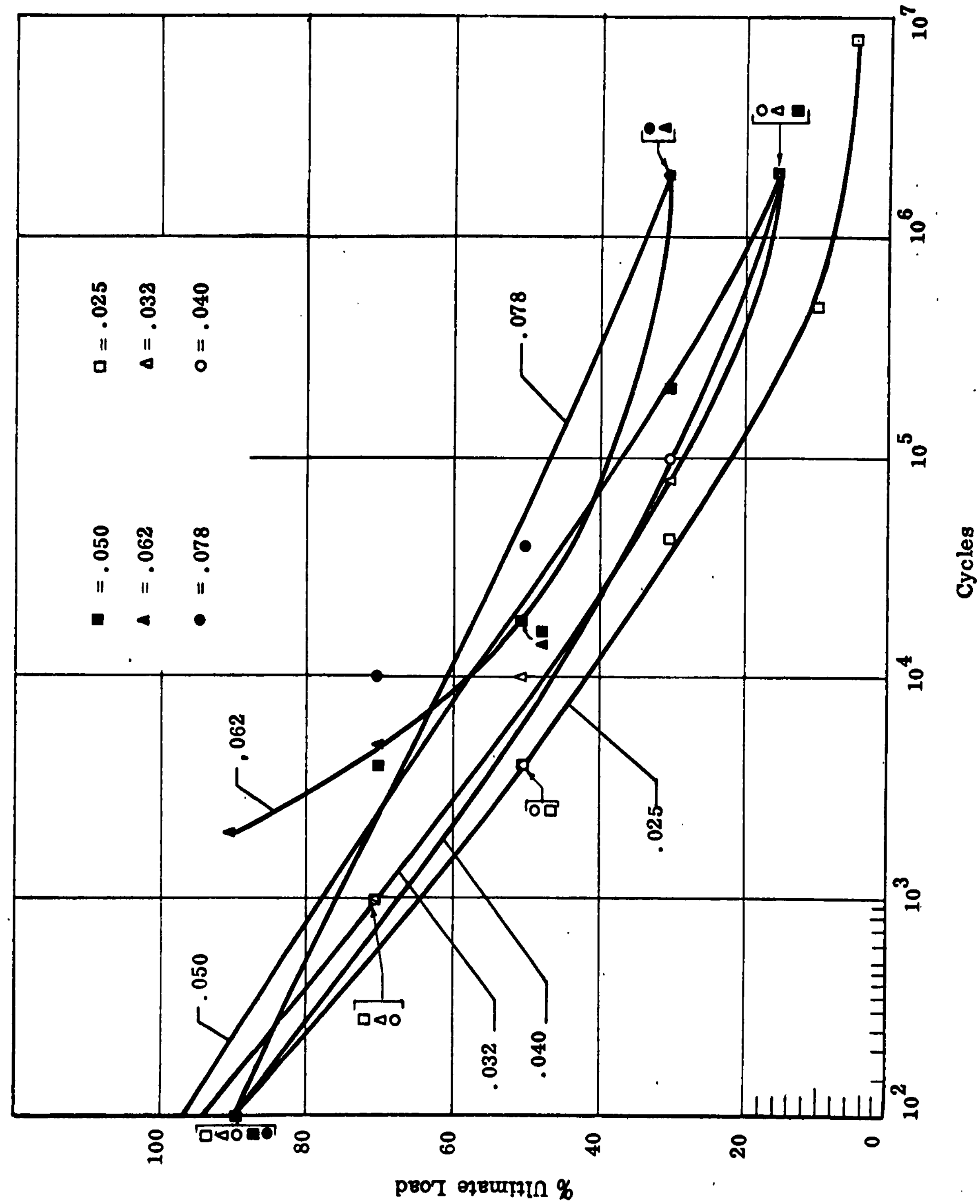
Load vs Temperature Properties - .062 Inch Spot Welded Sheet



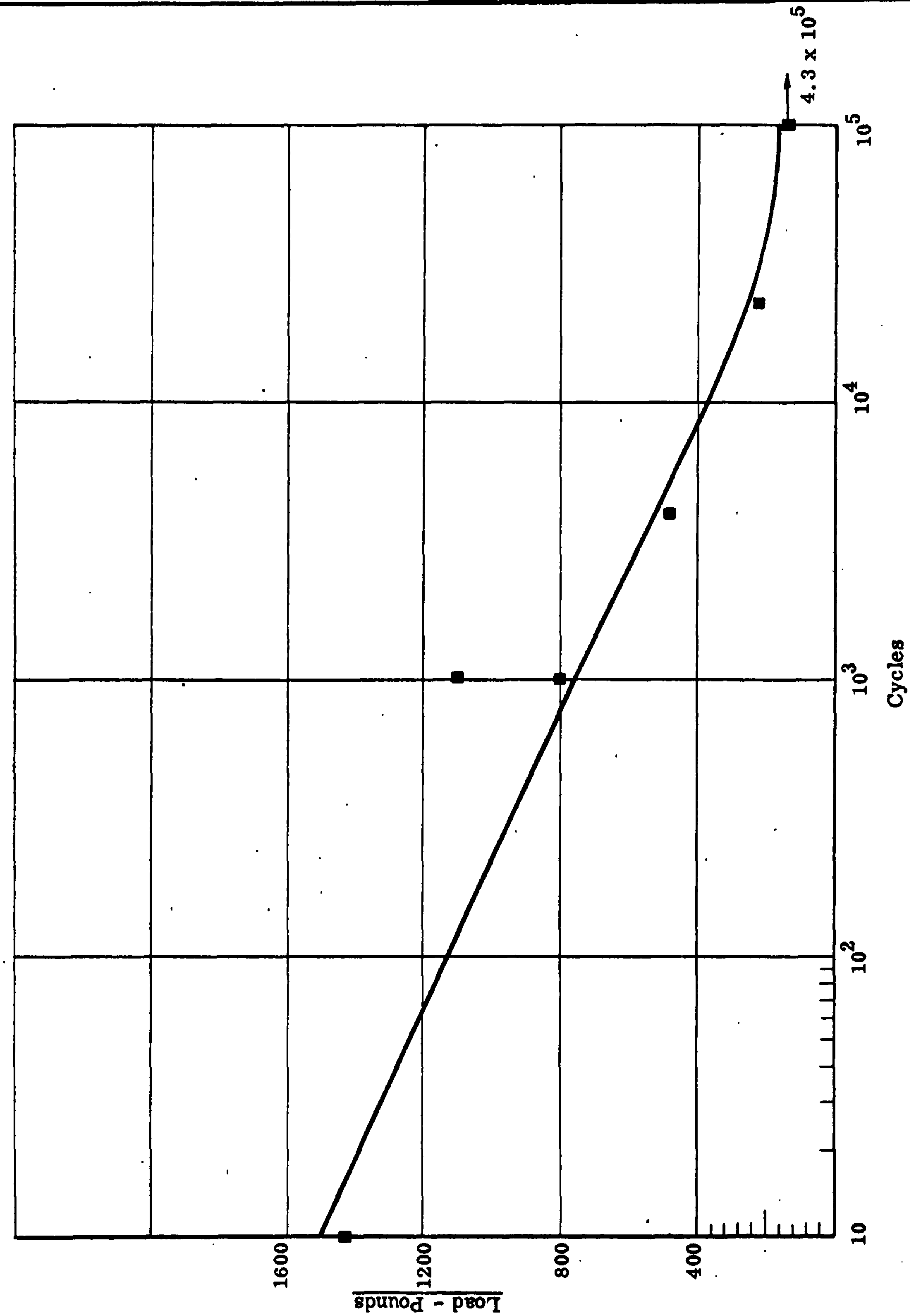
Load vs Temperature Properties - .078 Inch Spot Welded Sheet



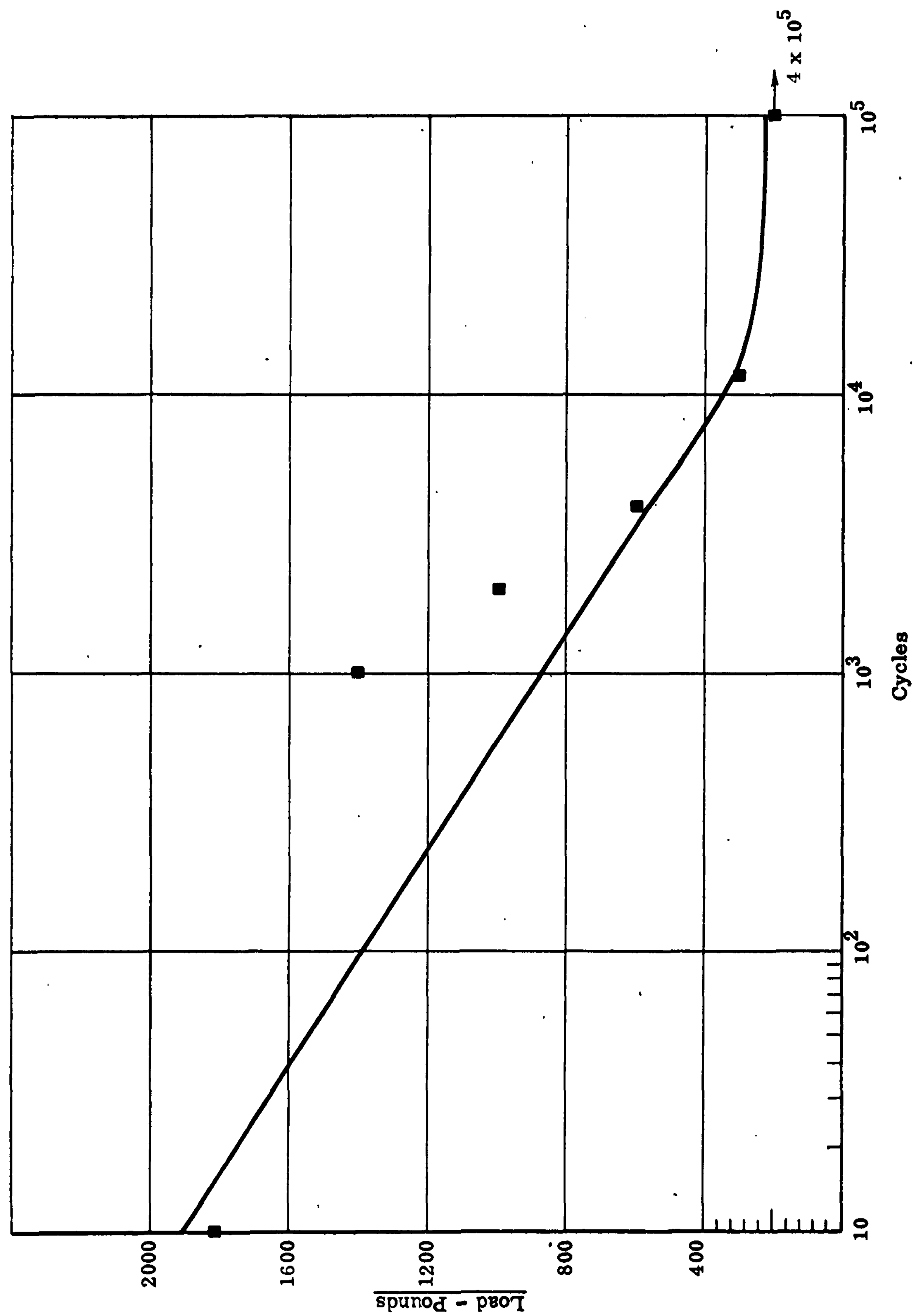
Pull-out Fatigue Tests - A110AT Spot Welded Sheet - Room Temperature



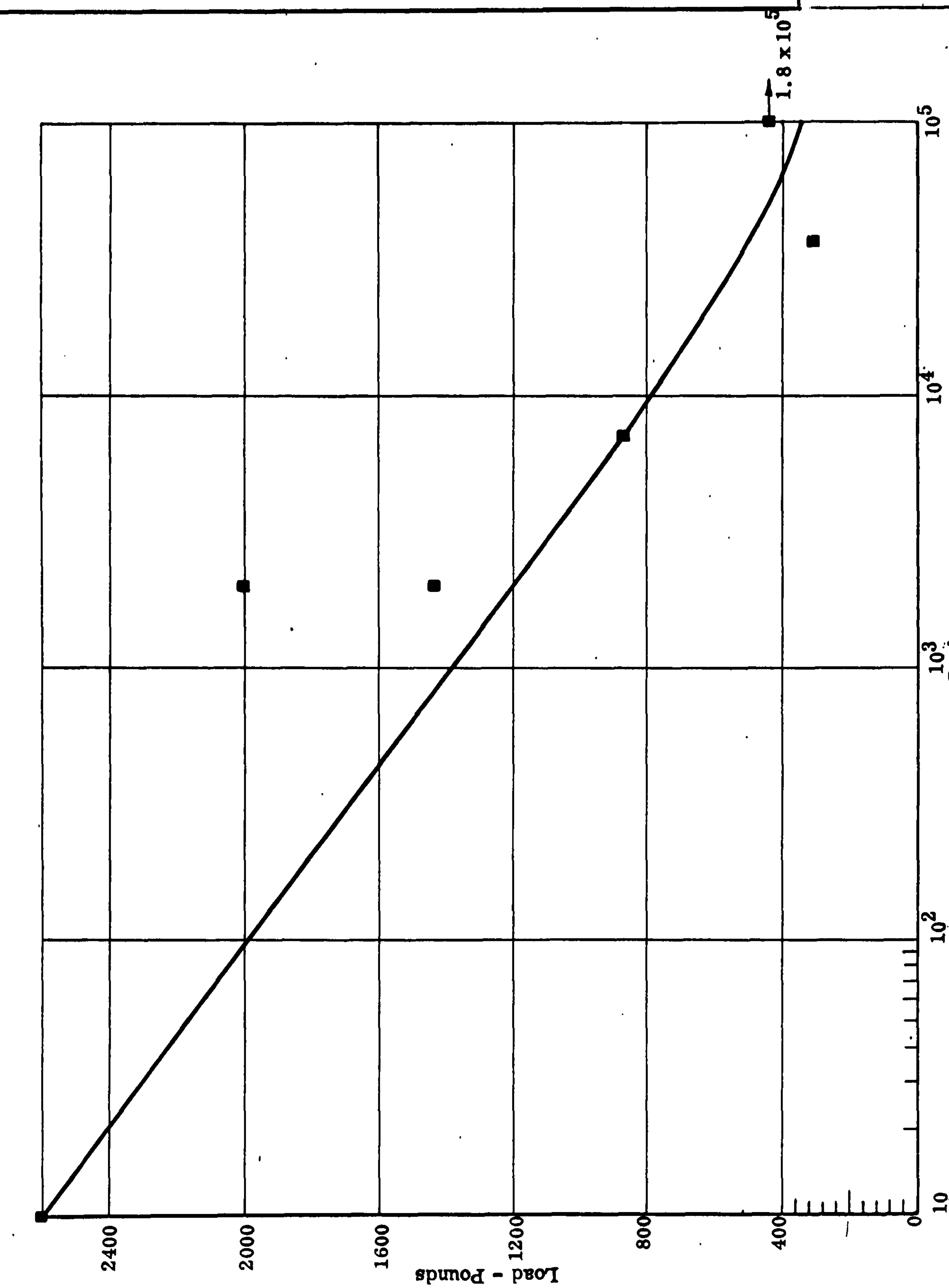
Pull-Out Fatigue Tests - A110AT Spot Welded Sheet - Room Temperature



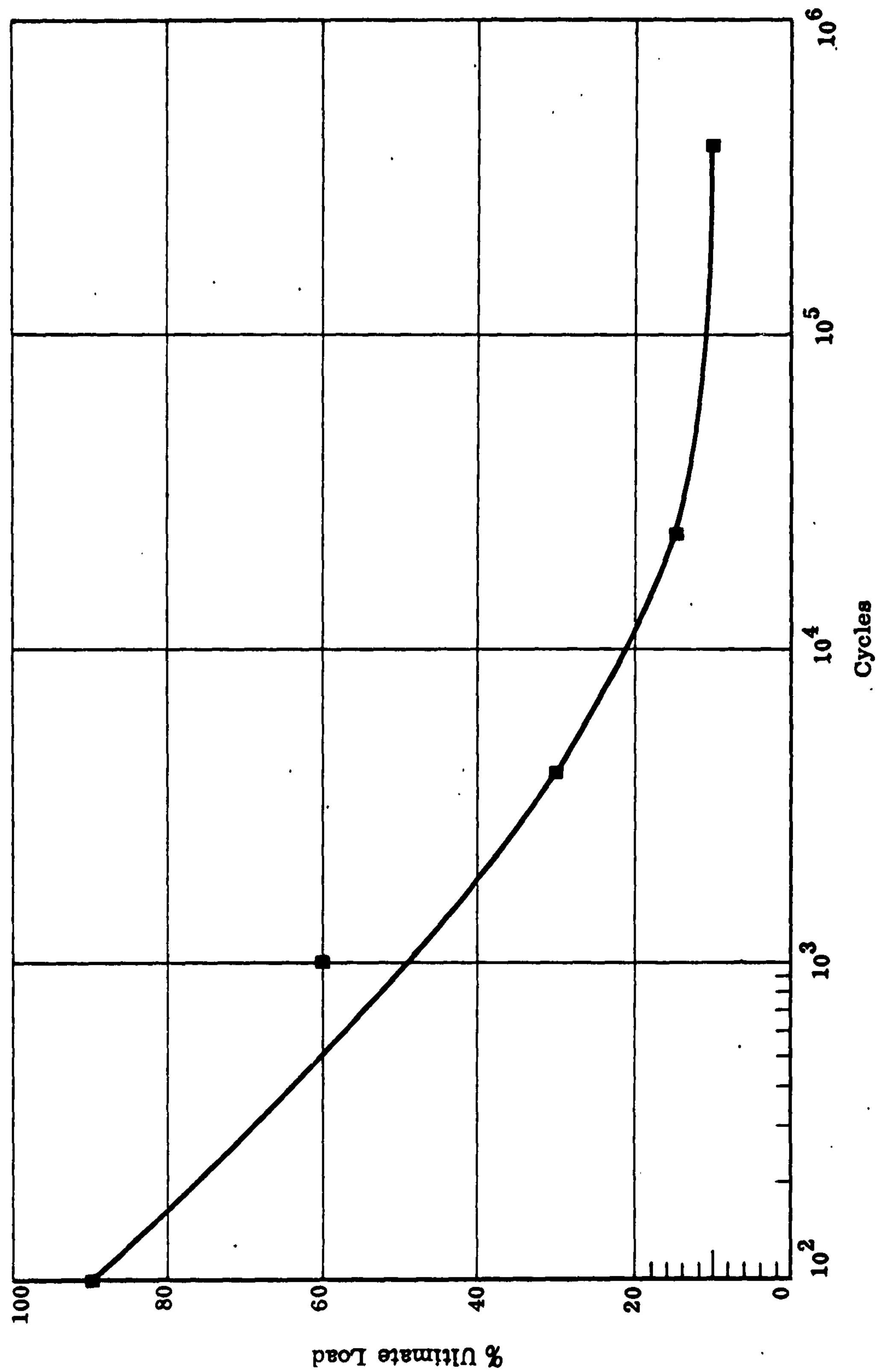
Tensile Shear Fatigue Tests - .025 Inch Spotwelded Sheet - Room Temperature



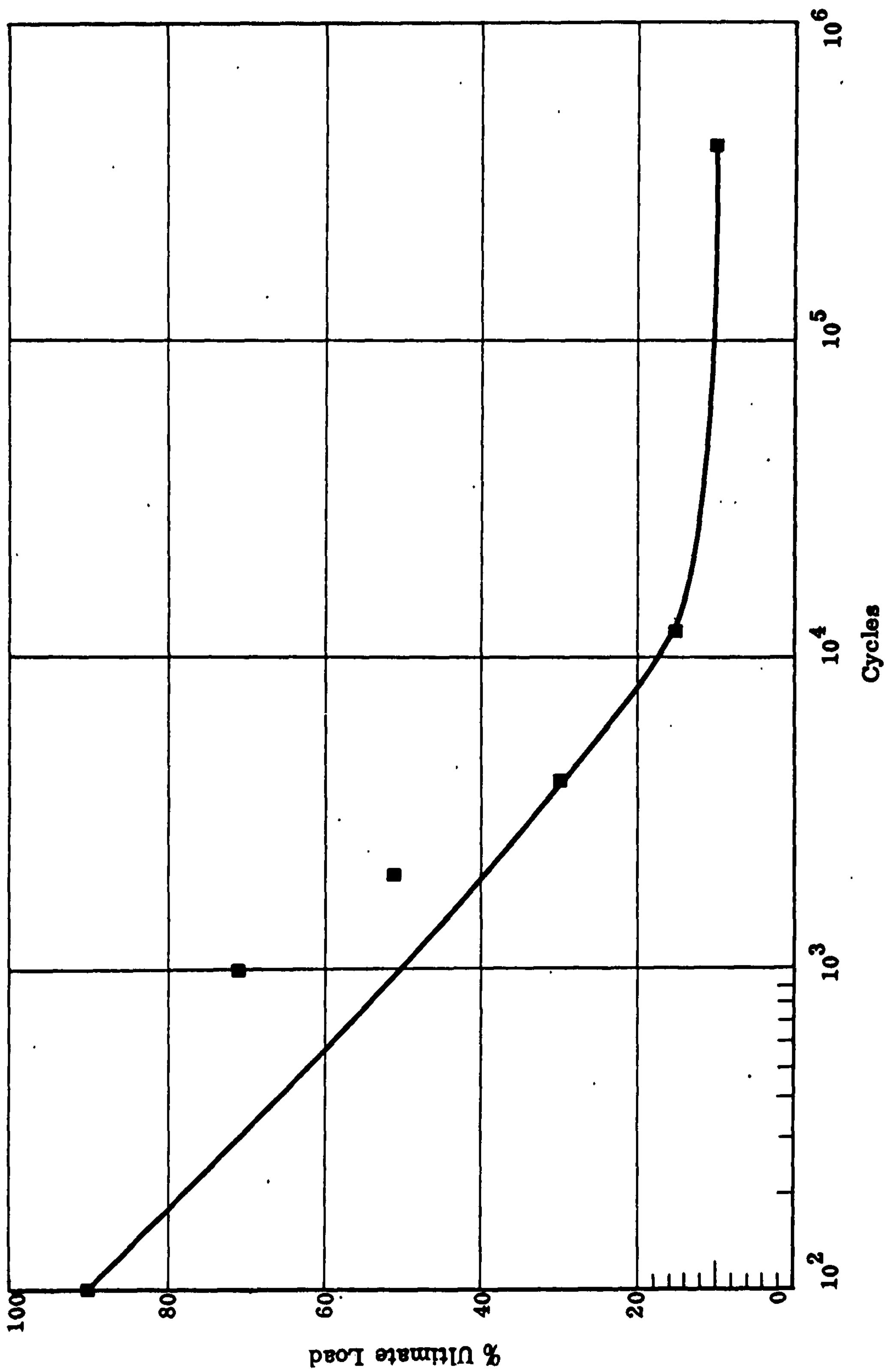
Tensile Shear Fatigue Test - .032 Inch - Spot Welded Sheet - Room Temperature



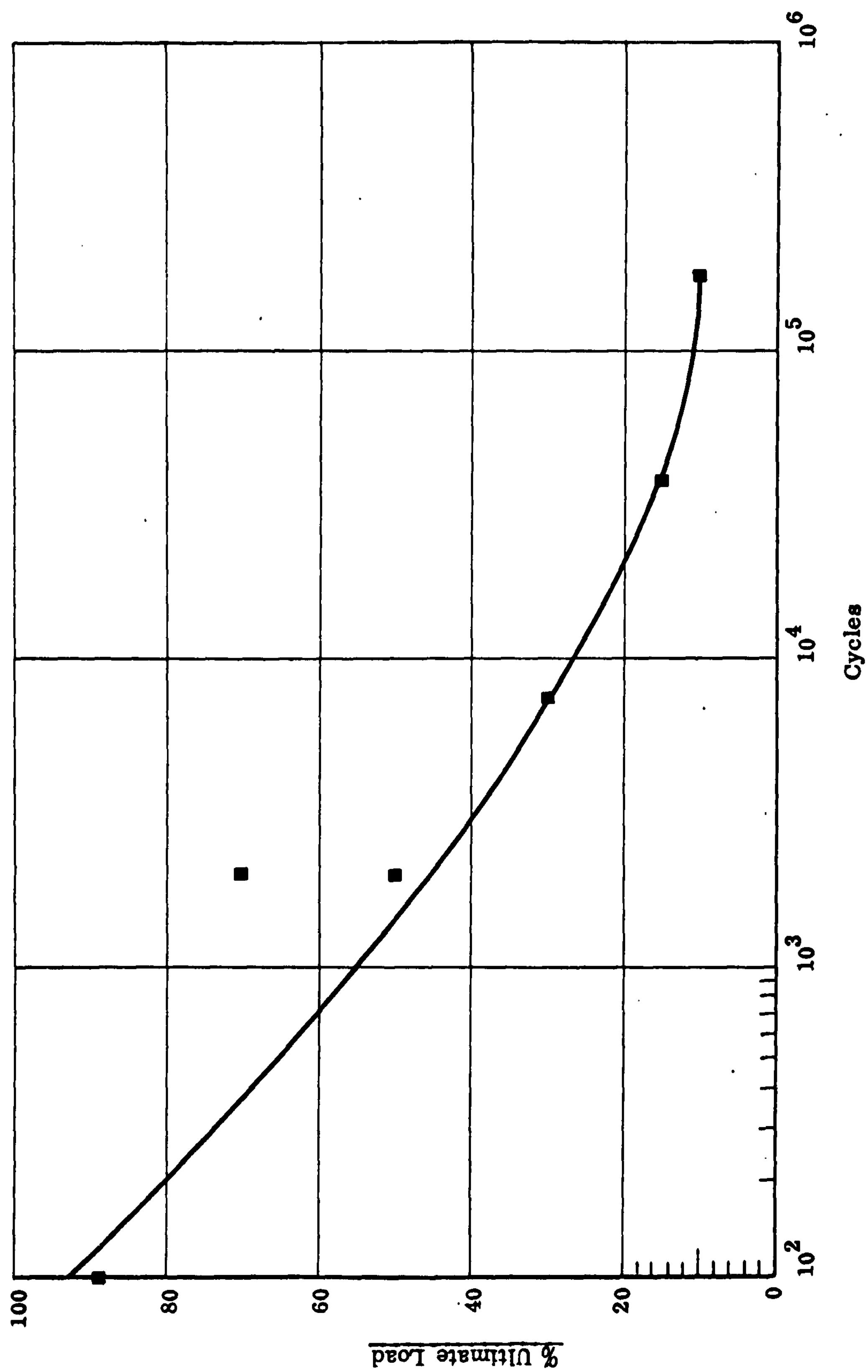
Tensile Shear Fatigue Tests - .040 Inch Spot Welded Sheet - Room Temperature



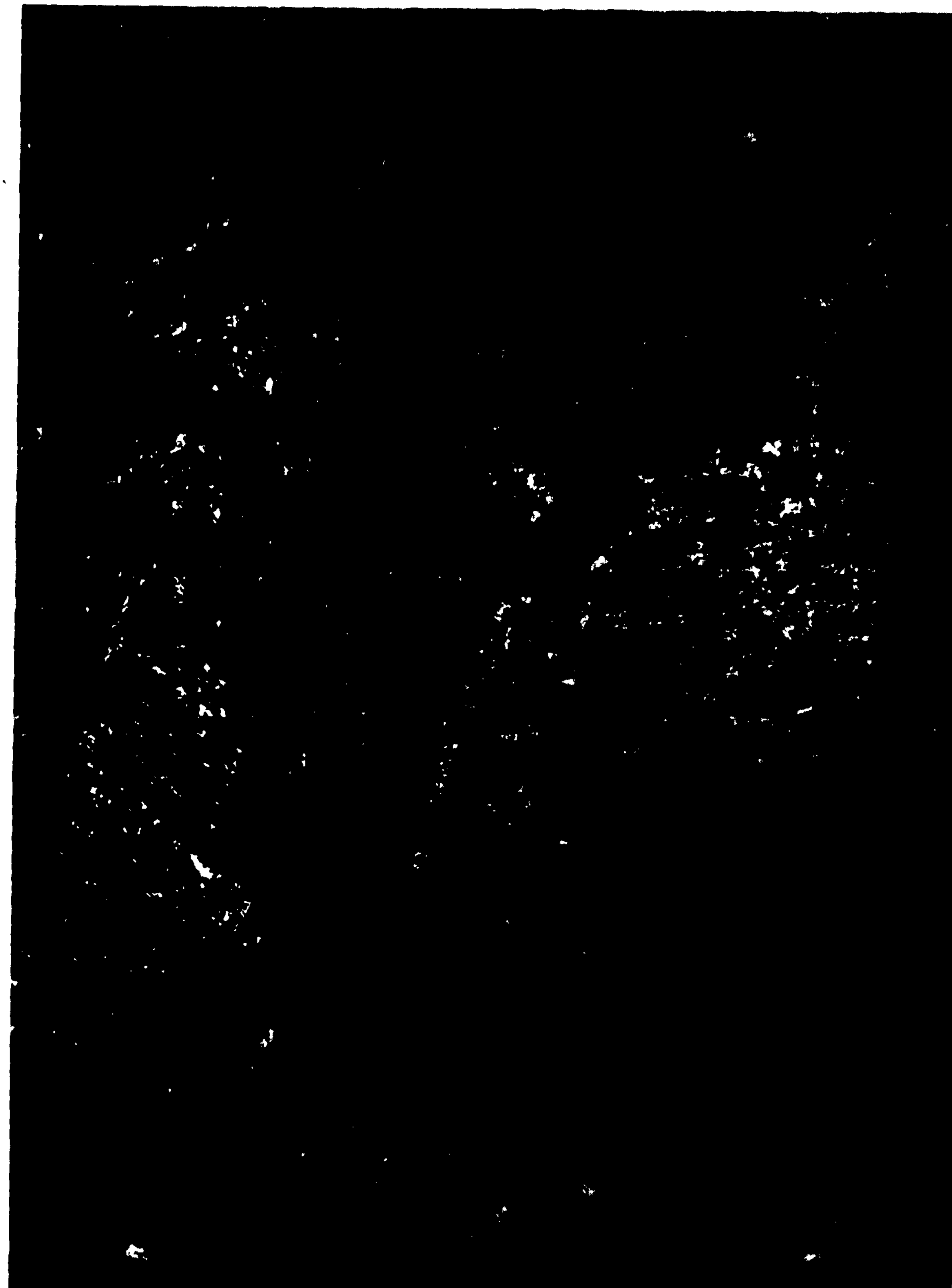
Tensile Shear Fatigue Tests - .025 Inch Spot Welded Sheet - Room Temperature



Tensile Shear Fatigue Tests - .032 Inch Spot Welded Sheet - Room Temperature



Tensile Shear Fatigue Tests - .040 Inch Spot Welded Sheet - Room Temperature



MECHANICAL PROPERTIES OF 6AL-4V TITANIUM

MATERIAL IDENTIFICATION (COML.)	MATERIAL STATUS
6Al-4V Titanium	Semi-Production
HEAT OR BATCH NUMBER	**FORM**
M-8749	.064 Sheet

PROCESSING CONDITION (1) As welded Mill Annealed (2) Welded and Aged At 1000° For 4 Hours (3) Welded and Sol. Treated At 1700° For 30 Minutes - Then Aged at 1000°F For 4 Hours.

OBJECT OF TEST	RAC DATA REF.
To Evaluate Fusion Butt Welding of 6Al-4V In The Annealed and Aged Conditions.	MRP Report No. 58-99-1

SPECIMEN TYPE
Standard Sheet Metal and Bend Test Specimens Per Federal Test Method Standard No. 151a dated May 6, 1959

TEST METHOD: Standard Sheet Metal and Bend Test Specimens Tested in Accordance With Federal Test Method No. 151a dated May 6, 1959

CHEMICAL ANALYSIS AS SUPPLIED BY PRODUCER

C	Fe	N_2	Al	V	H_2	Ti
.029	.11	.008	6.0	4.1	.004	Remainder

BASE METAL AND WELD TENSILE TEST VALUES

Condition	Yield 2% Offset psi	Ultimate psi	Elongation % in 2"	Location of Fracture
(As-welded RW)	**	124,600	1.0	Edge of weld
	**	117,500	1.0	Edge of weld
	118,700	134,900	2.0	Edge of weld
	125,080	141,630	2.0	In weld
	**	116,100	1.5	In weld
(As-welded GW)	143,200	161,100	2.5	In weld
	99,800	132,200	1.5	Edge of weld
	126,800	134,900	1.0	In weld
	**	124,710	2.0	In weld
	109,380	118,070	2.0	Edge of weld
Base Metal as-received	132,500	146,200	14.0	(Vendors test)
	134,500	144,900	14.0	(RAC-QCL test)
(Welded + Aged RW)	129,700	135,400	1.5	In weld
	128,700	142,300	9.0	Base metal
	**	107,600	1.5	In weld
	137,630	147,210	6.0	Base weld
	**	54,300	2.0	In weld

BASE METAL AND WELD TENSILE TEST VALUES (cont'd)

Condition	Yield 2% Offset psi	Ultimate psi	Elongation % in 2"	Location of Fracture
(Welded + Aged GW)	130,000	144,400	7.5	Base metal
	124,300	142,500	5.0	Base metal
	131,120	146,810	6.0	Base metal
	133,640	137,320	1.0	Base metal
(Base metal Aged)	128,000	145,600	12.5	Base metal
	130,200	144,500	11.0	Base metal
	129,500	143,600	12.5	Base metal
	130,100	144,550	12.5	
(Welded + ST + aged RW)	155,600	162,600	1.5	Base metal
	146,600	160,400	1.0	In weld
	146,200	152,600	1.0	Edge in weld
	150,000	152,420	0.5	Heat affect zone
	**	72,510	1.0	In weld
(Welded + ST + aged)	142,700	170,200	2.5	Edge of weld
	146,800	164,900	1.5	In weld
	155,630	162,830	2.0	Base metal
	147,160	151,320	2.0	In Weld
(Base metal ST + aged)	147,500	168,100	10.0	Base metal
	144,400	161,800	8.5	Base metal
	154,190	171,150	9.5	Base metal
	153,800	173,800	8.0	Base metal

** Test specimen failed before reaching yield point.
RW Weld reinforcement intact.
GW Weld reinforcement ground off.
ST Solution heat treated.

BEND TEST RESULTS

Condition	Results - Controlled Bend Bend Radius
Base metal - as received	Satisfactory - 4 x T - 105°
As welded	Fractured - 11 x T - 32°
Base metal - aged	Satisfactory - 4.5 x T - 105°
Welded + Aged	Fractured - 12.6 x T - 6°
Base metal - solution heat treated + aged	Satisfactory - 5.6 x T - 105°
Welded + solution heat treated + aged	Fractured - 10.4 x T - 21°

MECHANICAL PROPERTIES OF 5Cr-Mo-V STEEL

MATERIAL IDENTIFICATION (COML.) HWD #2	**MATERIAL STATUS** Production
HEAT OR BATCH NUMBER L-314	**FORM** Bar
PROCESSING CONDITION See Below	
OBJECT OF TEST Preliminary evaluation of HWD #2 Bar	**RAC DATA REF.** ERMR 3512, dated August 24, 1956

SPECIMEN TYPE

.505 dia. tensile specimen - same as ARTC-13T, July 1957

TEST METHOD:

Tensile tests as per ARTC-13T-1 (July 1957).

Two pieces of HWD #2, $3\frac{1}{2}$" x $3\frac{1}{2}$" x 6", were shipped to RAC for evaluation by Firth-Sterling. One piece, designated "A", was heat-treated by the supplier. The second piece, designated "B", was heat-treated by Hercules Heat Treat Co., Brooklyn, New York. After heat-treating, samples were cut from each piece and coded as shown on Page 3. Identical numbers were assigned to bars from each piece, with the appropriate "A" or "B" suffix.

The Firth-Sterling heat treat schedule was:

Charge at 1400°F, equalize; heat to 1850°F, equalize and soak one hour; salt quench at 1000°F, equalize and air cool; temper 4 hours at 1050°F, air cool; temper 4 hours at 1075°F to Rockwell C45-46, air cool.

The heat-treat schedule followed by Hercules Heat Treat Company was:

Charge at 1400°F, equalize; heat to 1850°F, equalize and soak one hour; quench in salt at 1000°F, air cool; temper 4 hours at 1050°F ±25°F, air cool; temper 4 hours at 1075°F ±25°F, air cool.

CHEMICAL COMPOSITION

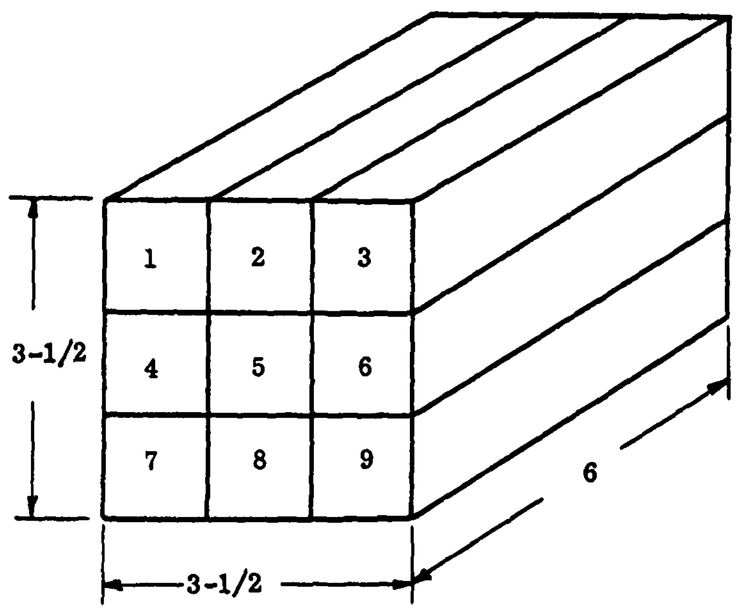
	Cr	Mo	V	Si	Mn	C	S	P	Ni	W	Fe
HWD #2 (Nominal)	5.25	1.35	.50	1.0		.37					Balance
HWD #2 (Heat L-314)	5.20	1.24	.47	1.12	.39	.37	.010	.025	.27	.15	Balance

TENSILE PROPERTIES

Test Condition	Specimen Location	Ult. KSI	.2% Yield KSI	% Elong. in 2"	Ult. KSI	.2% Yield KSI	% Elong in 2"
		Heat Treat "A"			Heat Treat "B"		
Room Temperature	1	224	202	12.5	216	192	13.0
	7	222	197	13.0	217	190	13.0
Room Temperature After 10 hours @ 1000°F	8	215*	194	14.0	216	184	11.5
Room Temperature After 100 hours @ 1000°F	5	180	155	15.5	199	183	10.5
Room Temperature After 100 hours @ 1000°F, plus 10 hours @ 1100°F	3	167**	141	17.0	187	158	14.5
600°F (½ hr. soak)	2	192	178	12.0	187	163	15.0
800°F (½ hr. soak)	4	185	157	14.0	183	153	14.0
1000°F (½ hr. soak)	6	140	114	-	146	127	16.0

* Note Failure - Page 3 of 19

** Note Failure - Page 3 of 19



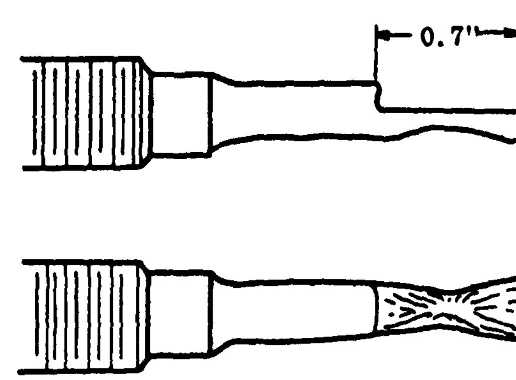
Conditions

1. Room Temp. - No Exposure
2. At 600°F - 1/2 Hr. Soak
3. Room Temp. - After 100 Hrs. at 1000°F Plus 10 Hrs. at 1100°F
4. At 800°F - 1/2 Hr. Soak
5. Room Temp. - After 100 Hrs. at 1000°F
6. At 1000°F - 1/2 Hr. Soak
7. Room Temp. - No Exposure
8. Room Temp. - After 10 Hours at 1000°F
9. Not used

SPECIMEN 8A

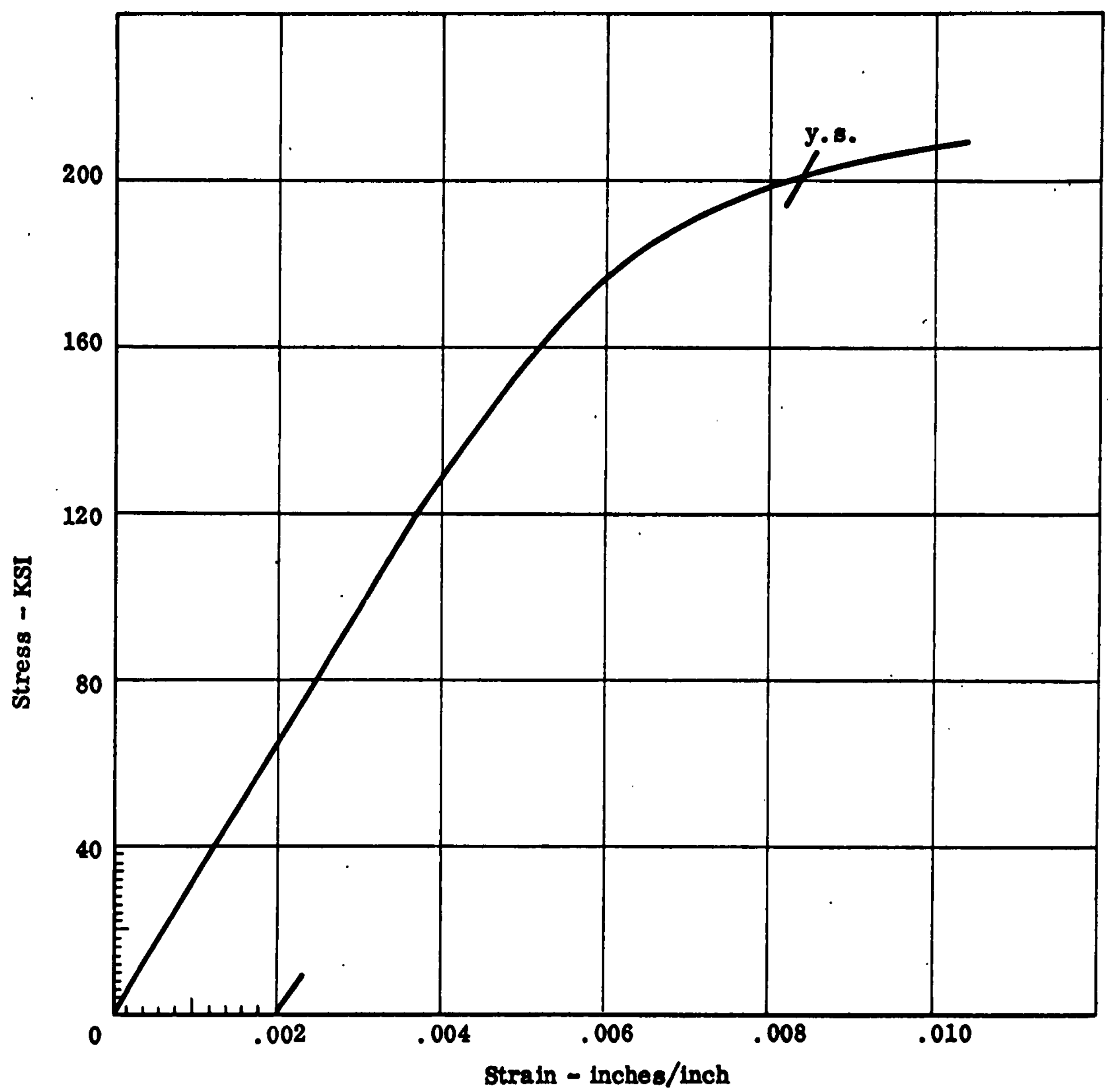
Noticeable reduction in area - longitudinal crack indicating start of failure as in 3A.

SPECIMEN 3A

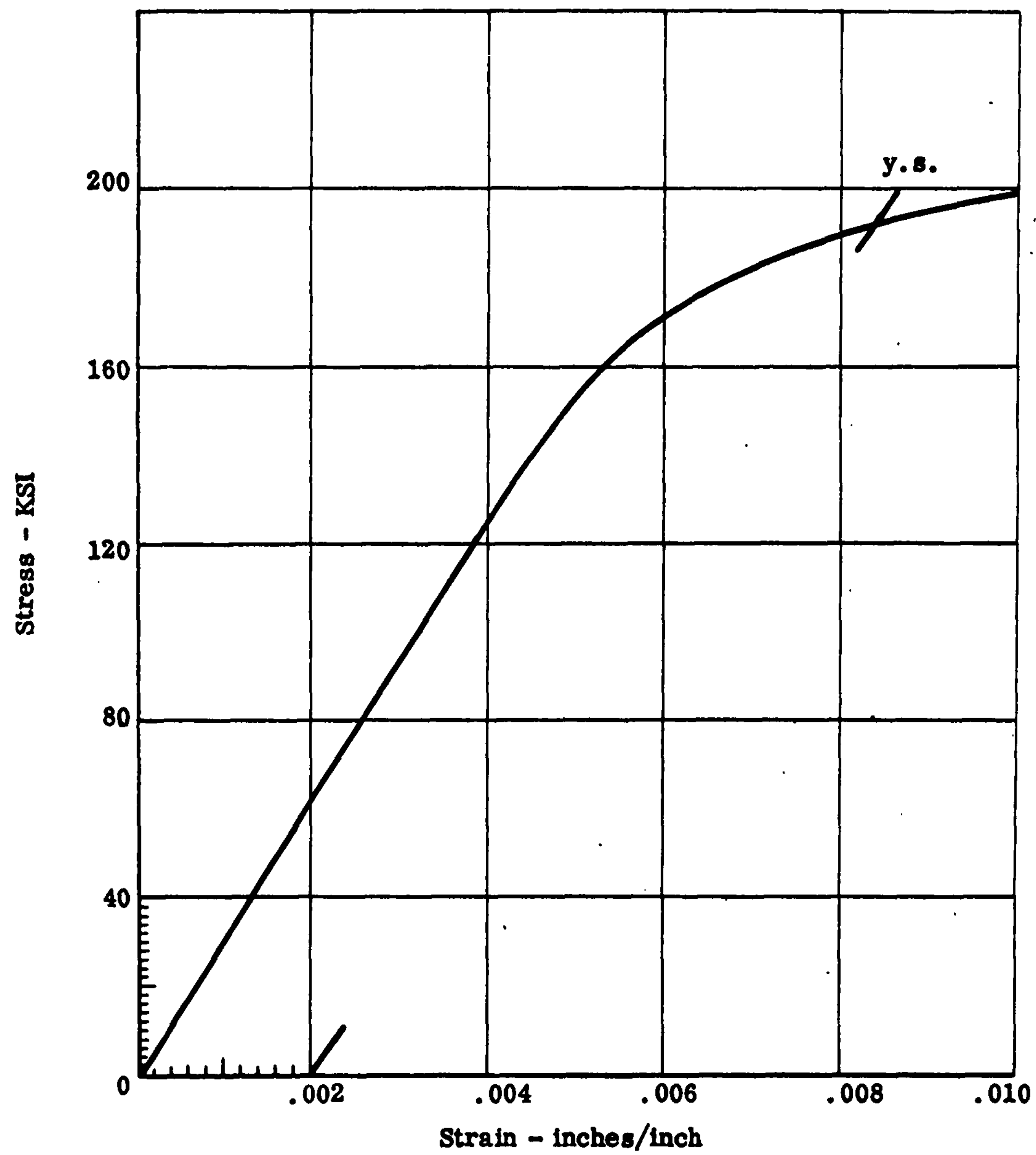


Reduction in area at center section. Failure along longitudinal axis.

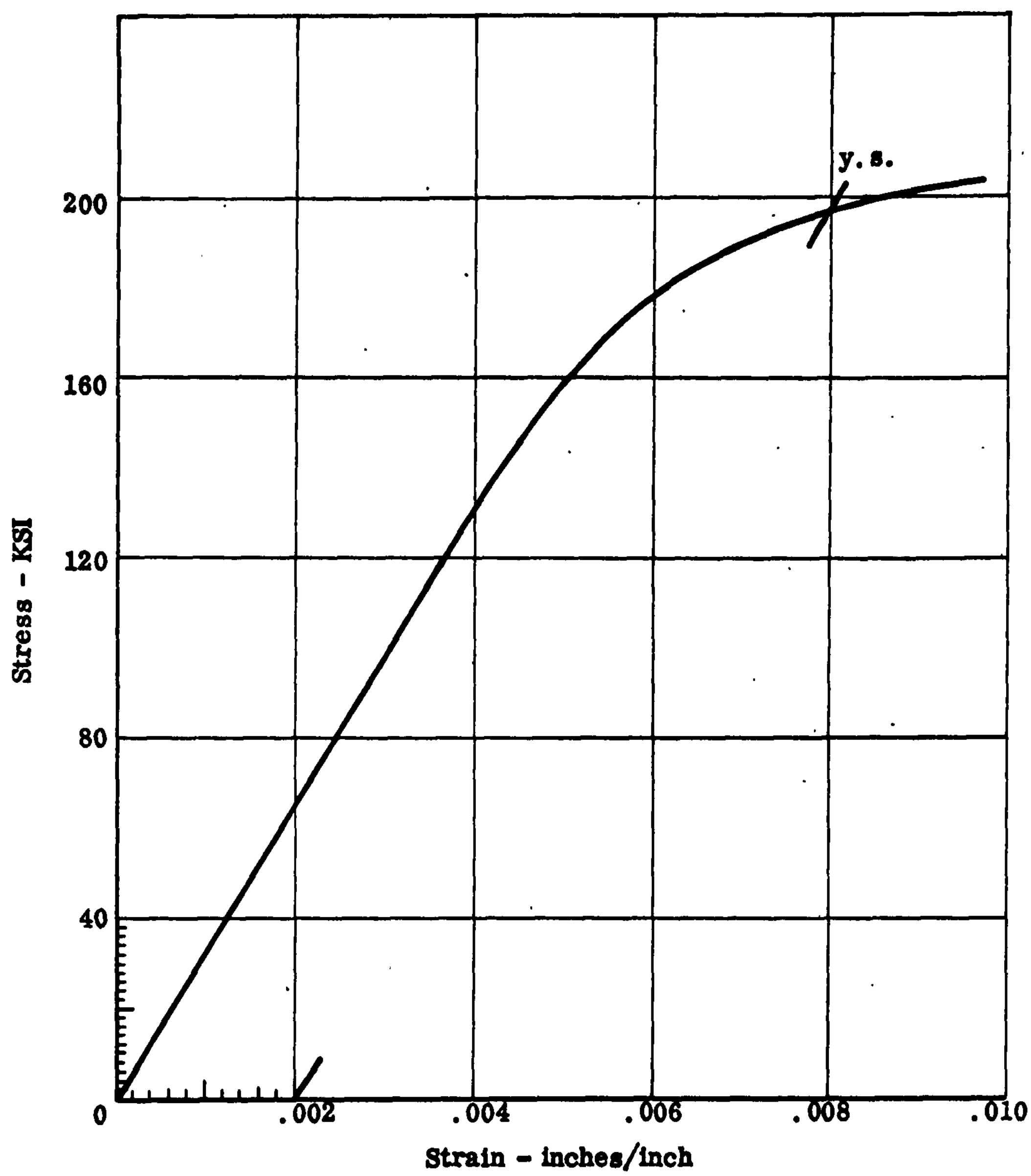
Location of Specimens - Condition of Test



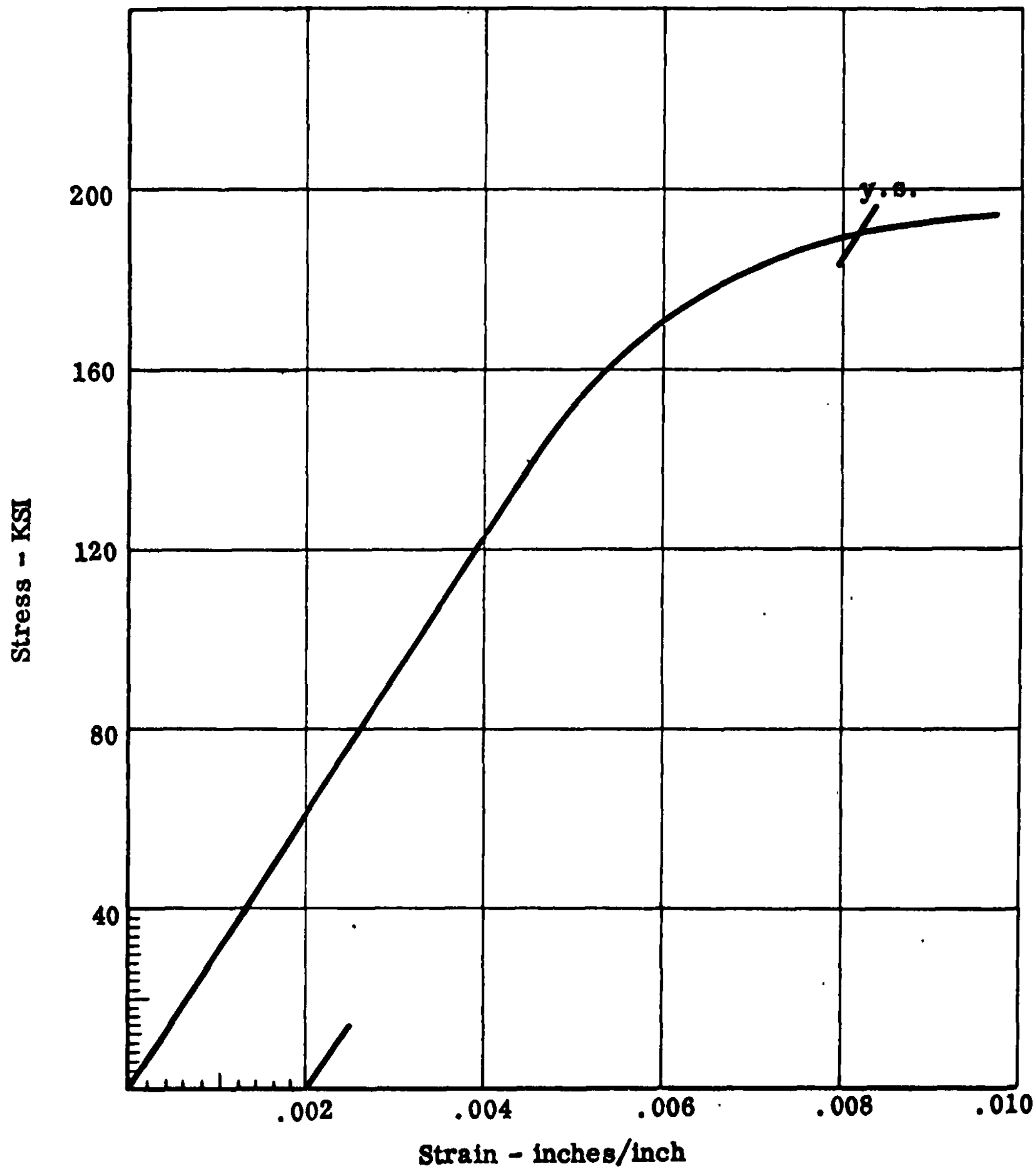
Stress vs Strain
Specimen 1A
Room Temperature - No Exposure



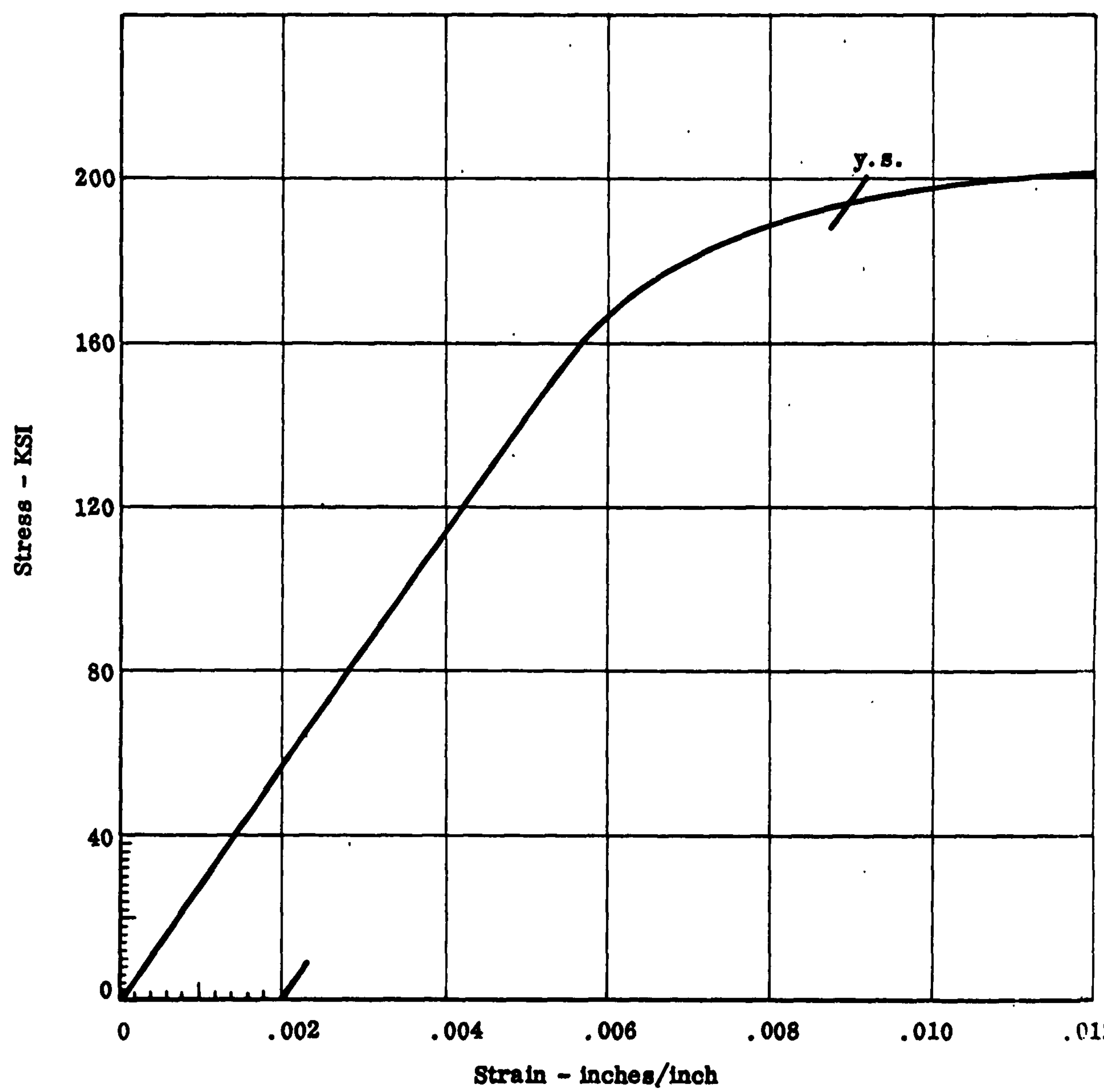
Stress vs Strain
Specimen 1B
Room Temperature - No Exposure



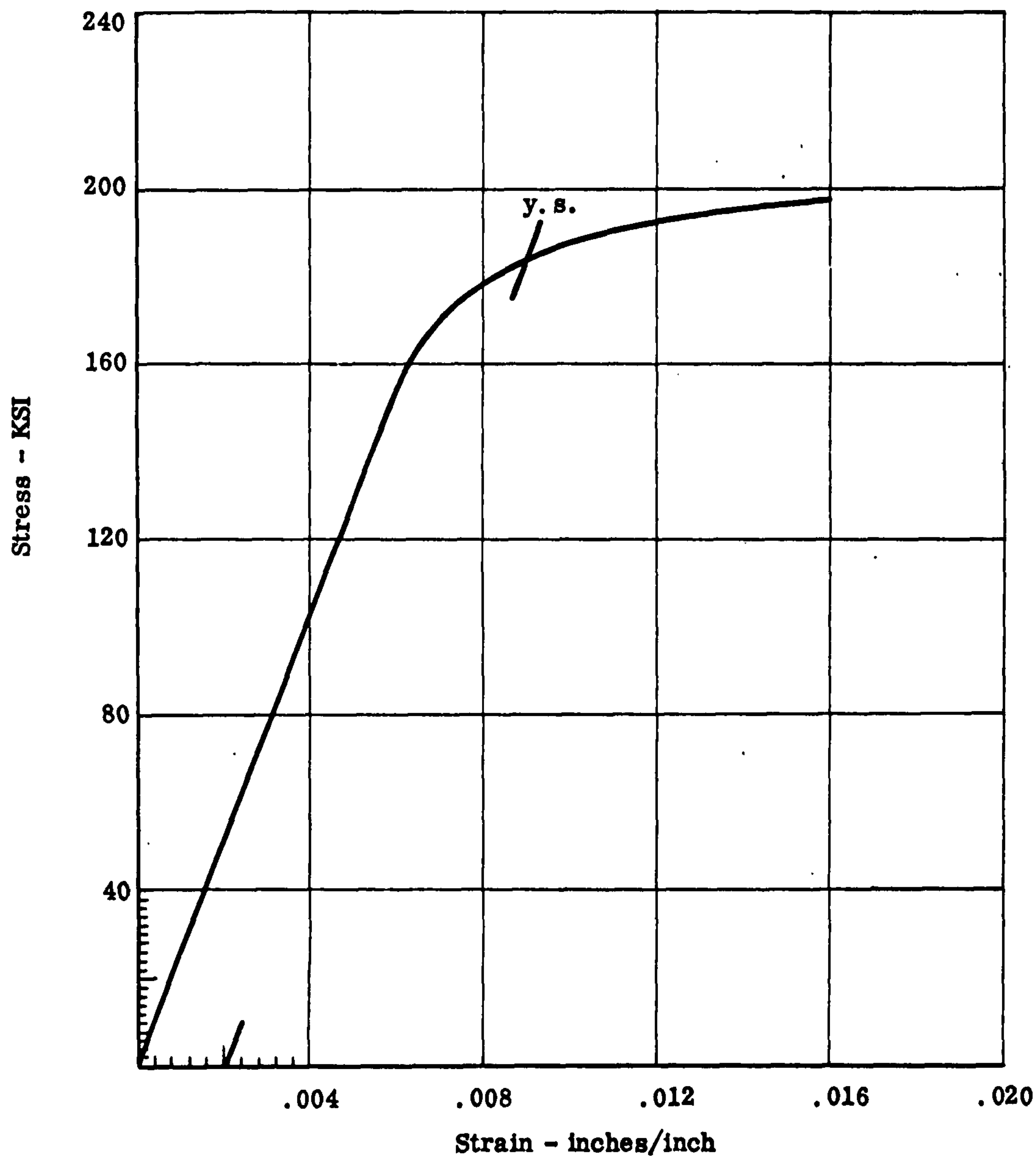
Stress vs Strain
Specimen 7A
Room Temperature - No Exposure



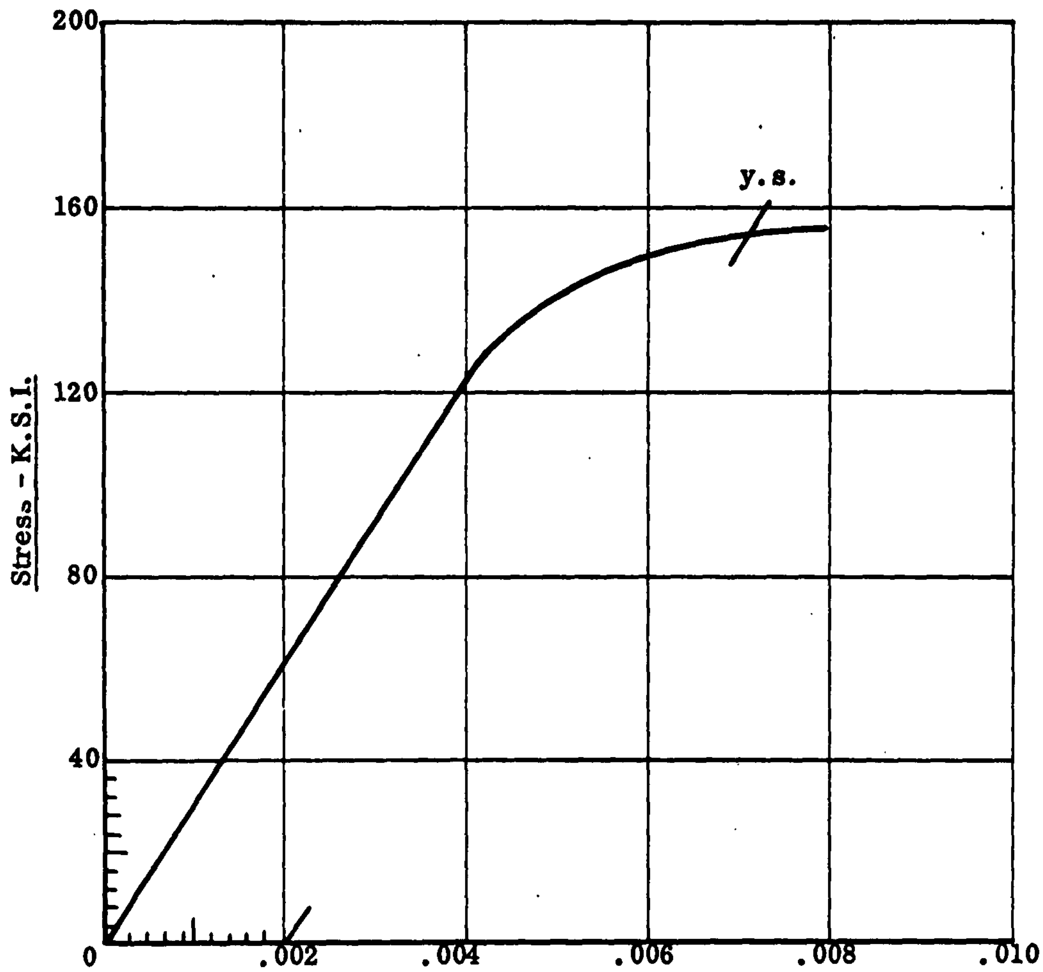
Stress vs Strain
Specimen 7B
Room Temperature - No Exposure



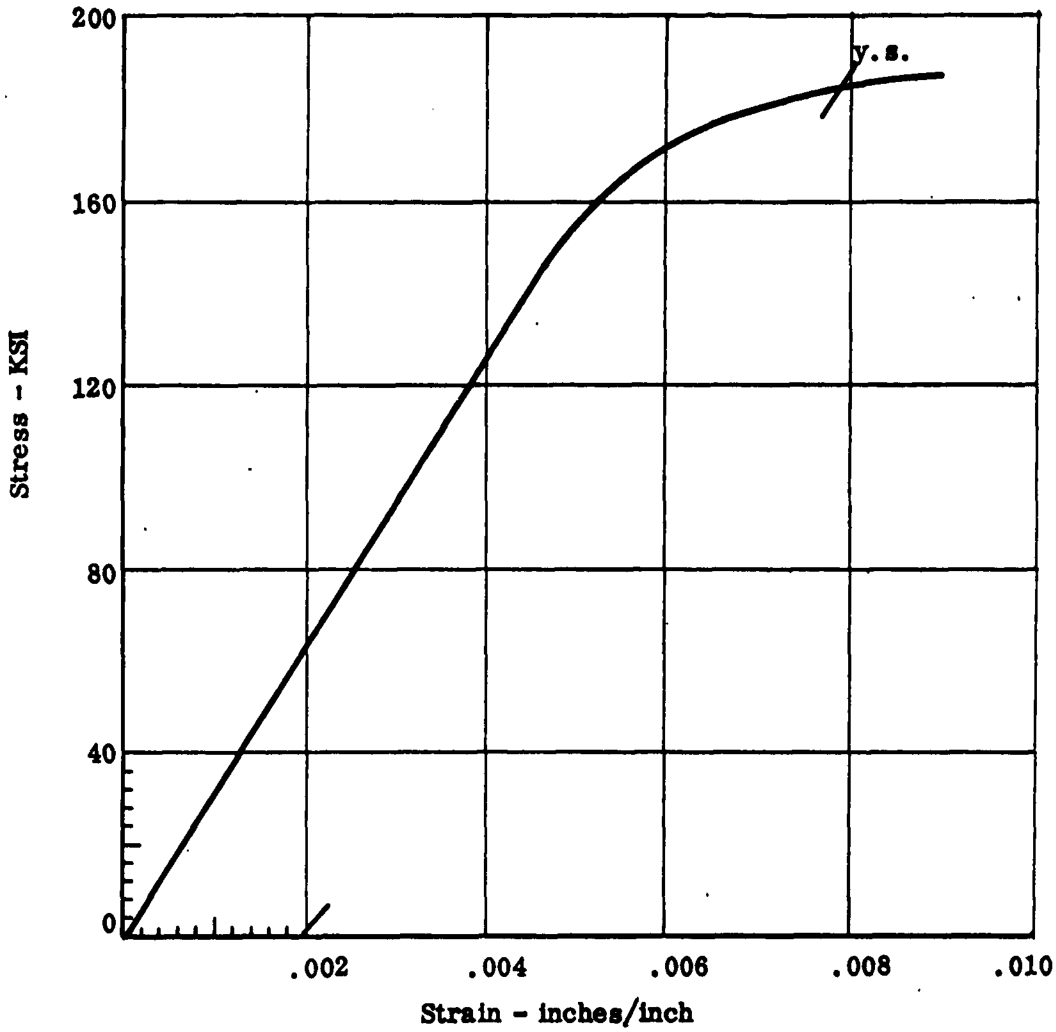
Stress vs Strain
Specimen 8A
Room Temperature - After 10 Hours at 1000°F



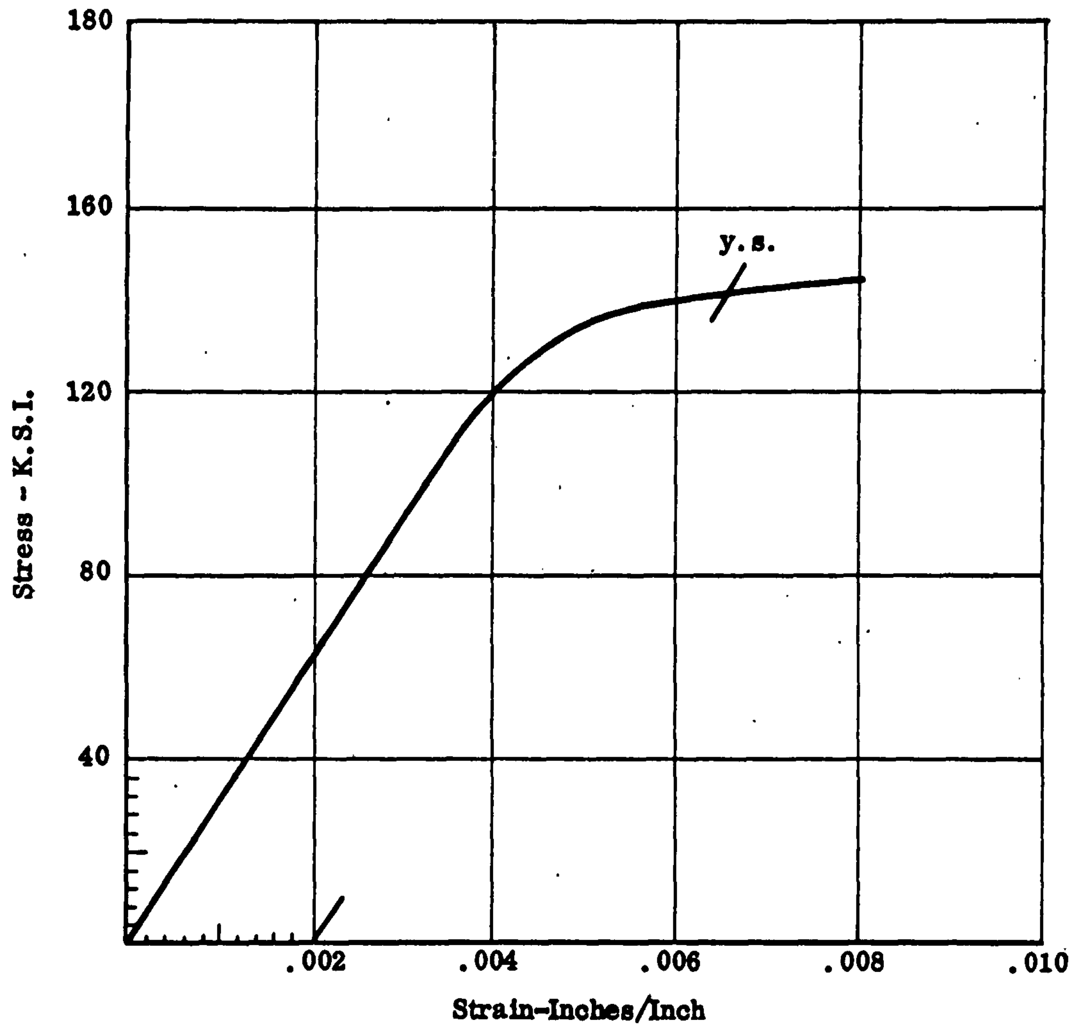
Stress vs Strain
Specimen 8B
Room Temperature - After 10 Hours at 1000°F



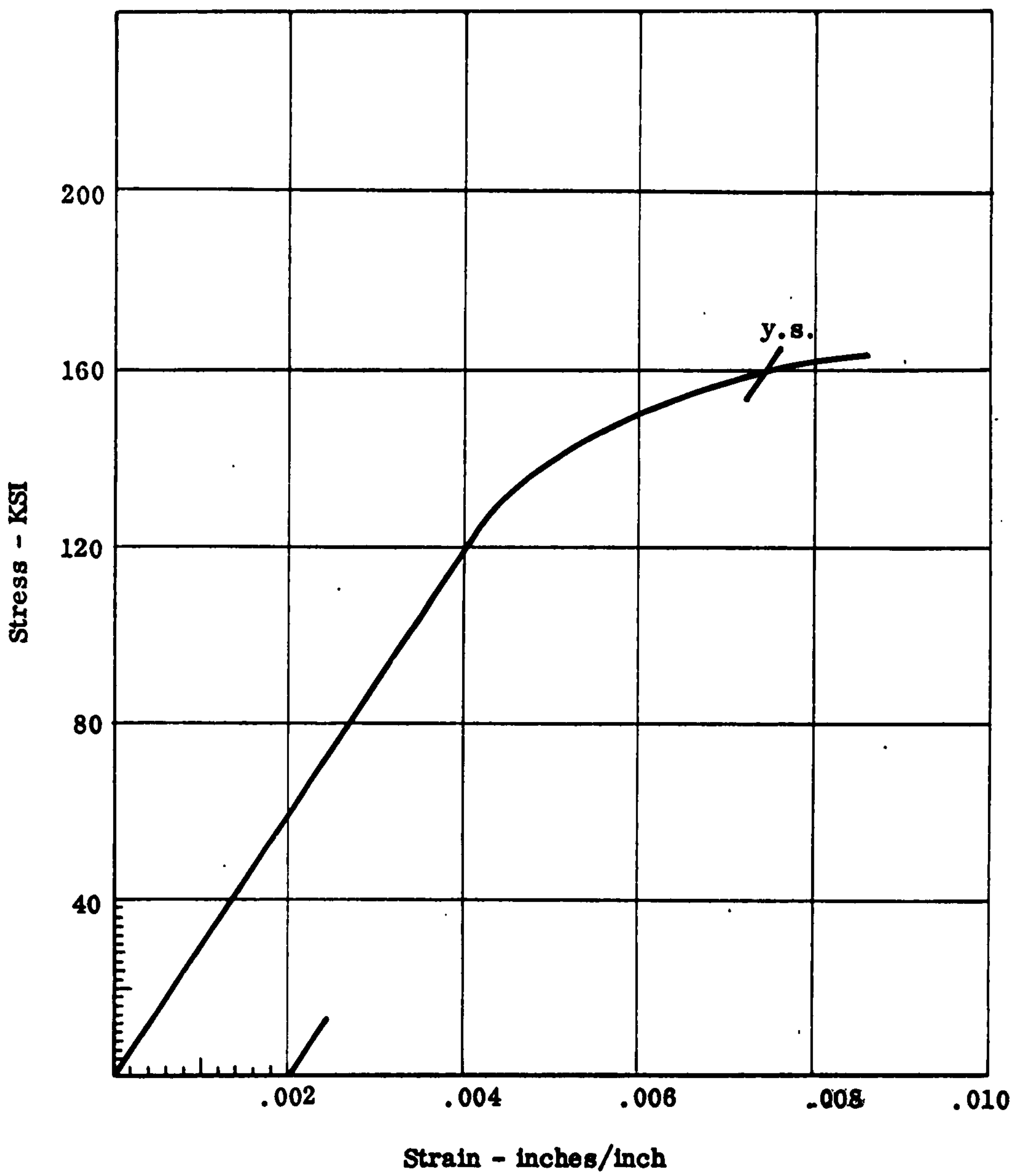
Stress - vs. Strain
Specimen 5A
Room Temperature - After 100 Hours at 1000°F



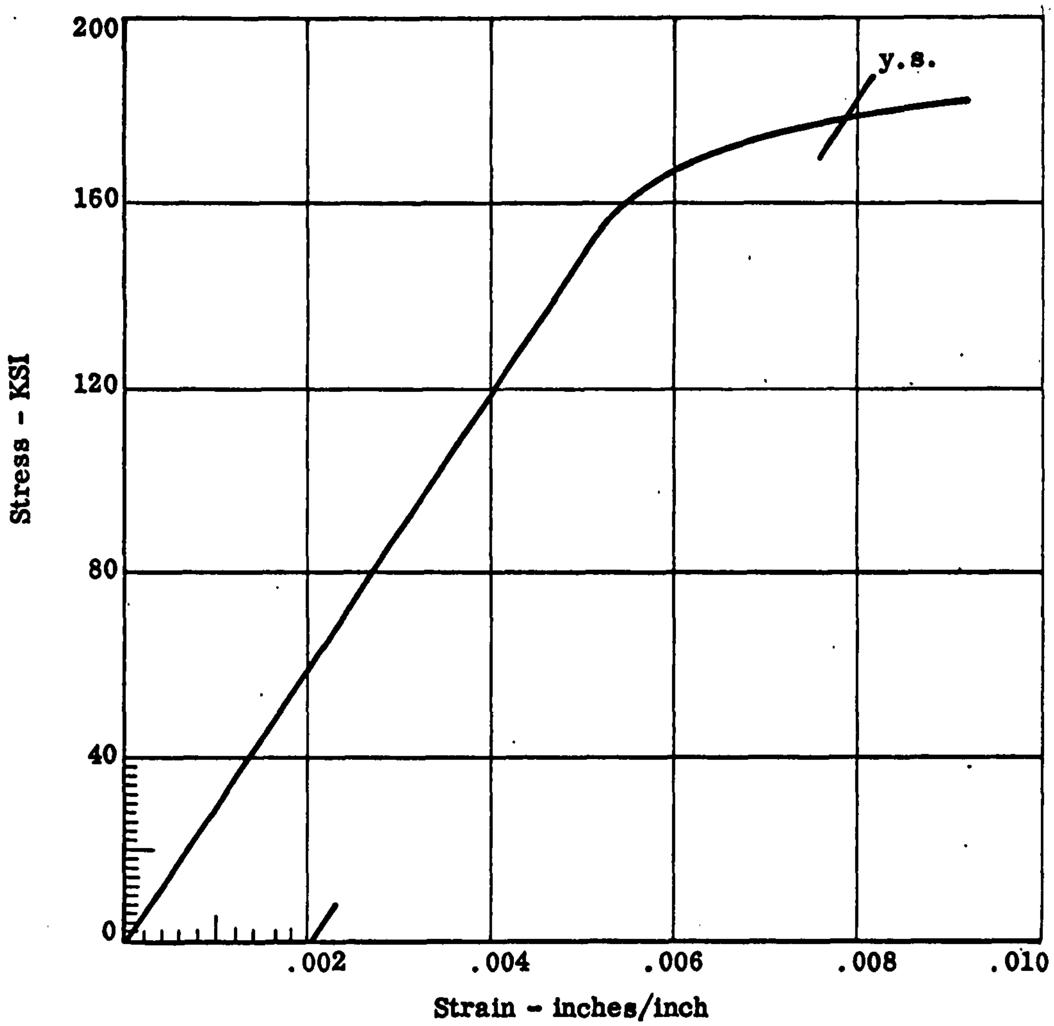
Stress vs Strain
Specimen 5B
Room Temperature - After 100 Hours at 1000°F



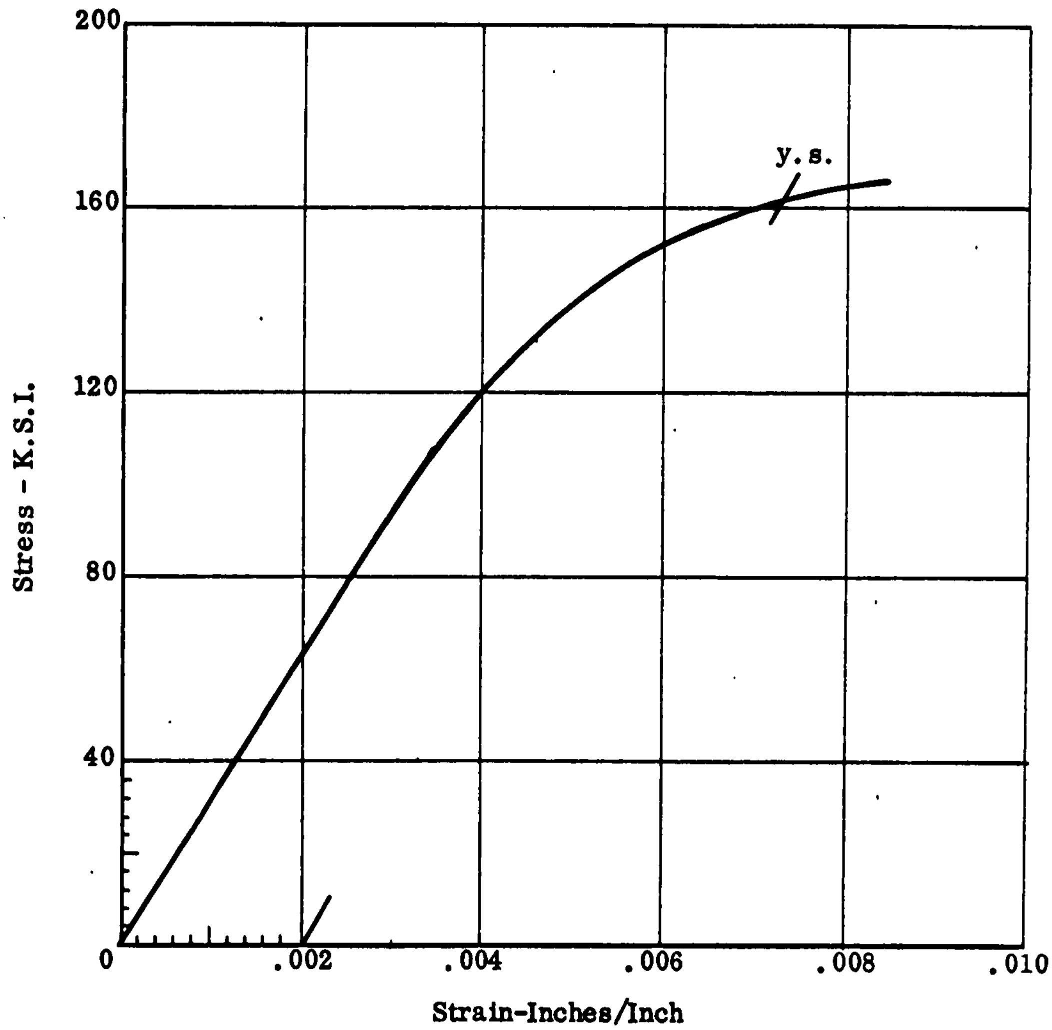
Stress vs. Strain
Specimen 8A
Room Temperature - After 100 Hours at 1000°F
Plus 10 Hours at 1100°F



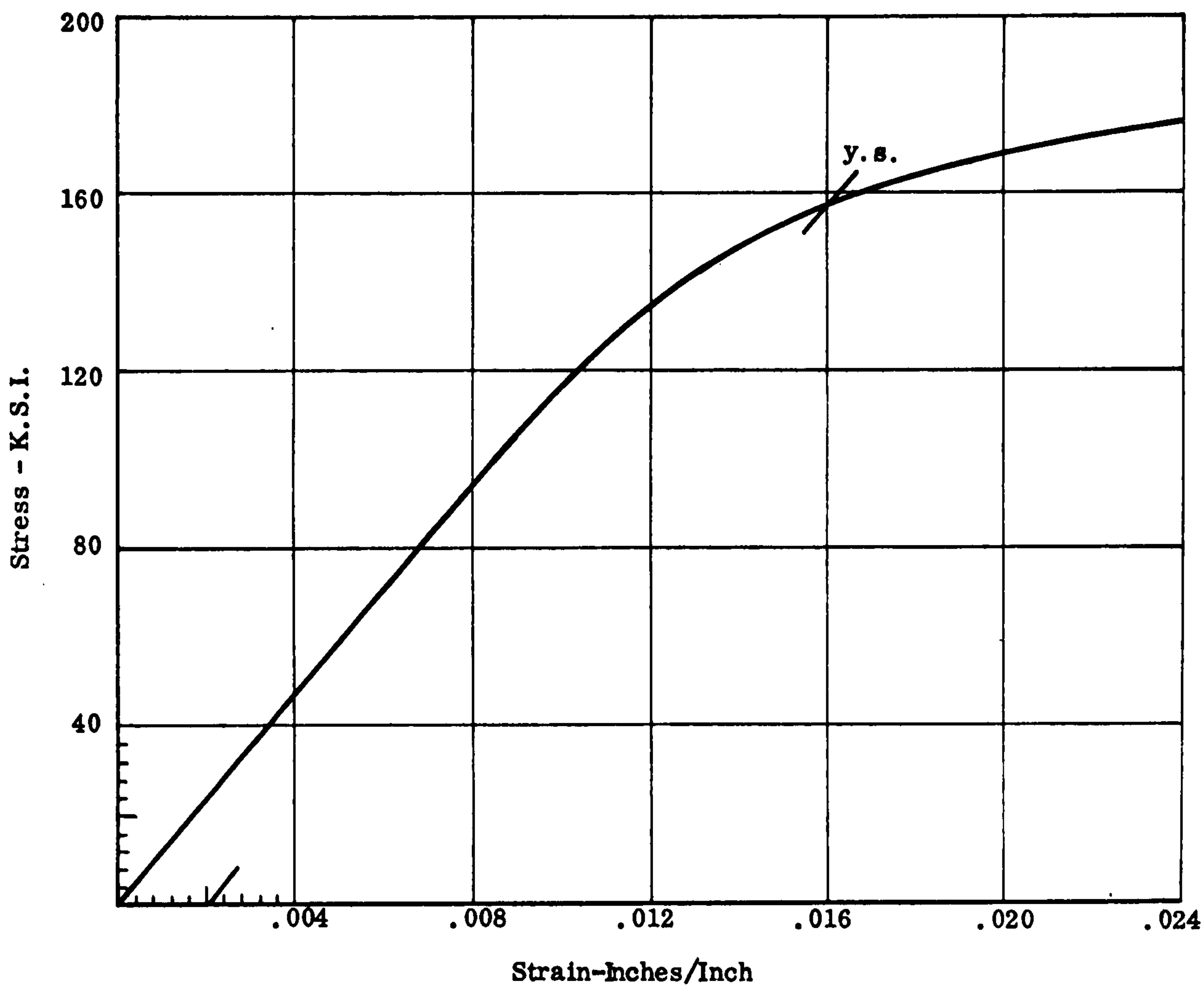
Stress vs Strain
Specimen 3B
Room Temperature - After 100 Hours at 1000°F
Plus 10 Hours at 1100°F



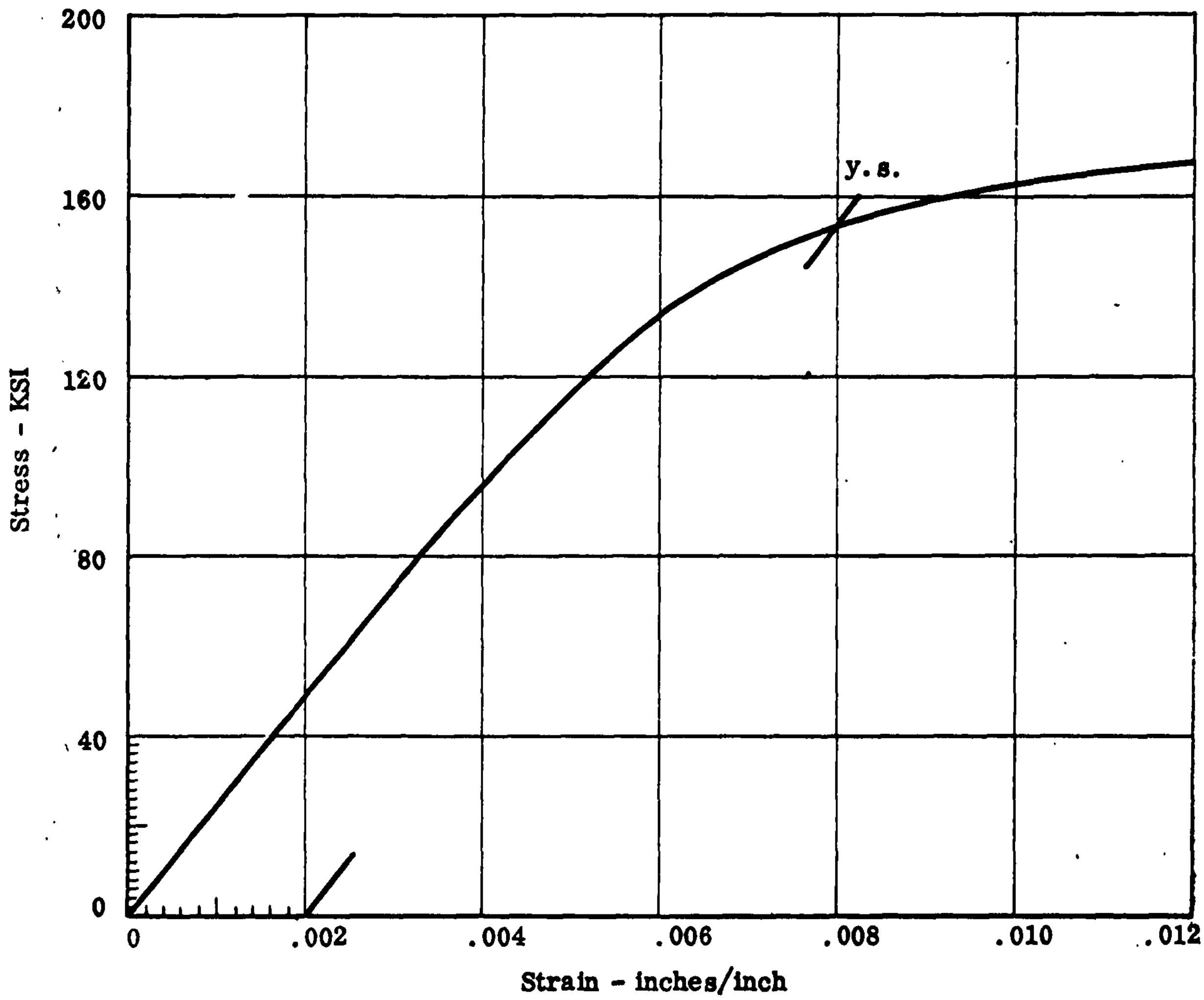
Stress vs Strain
Specimen 2A
At 600°F - Half Hour Soak



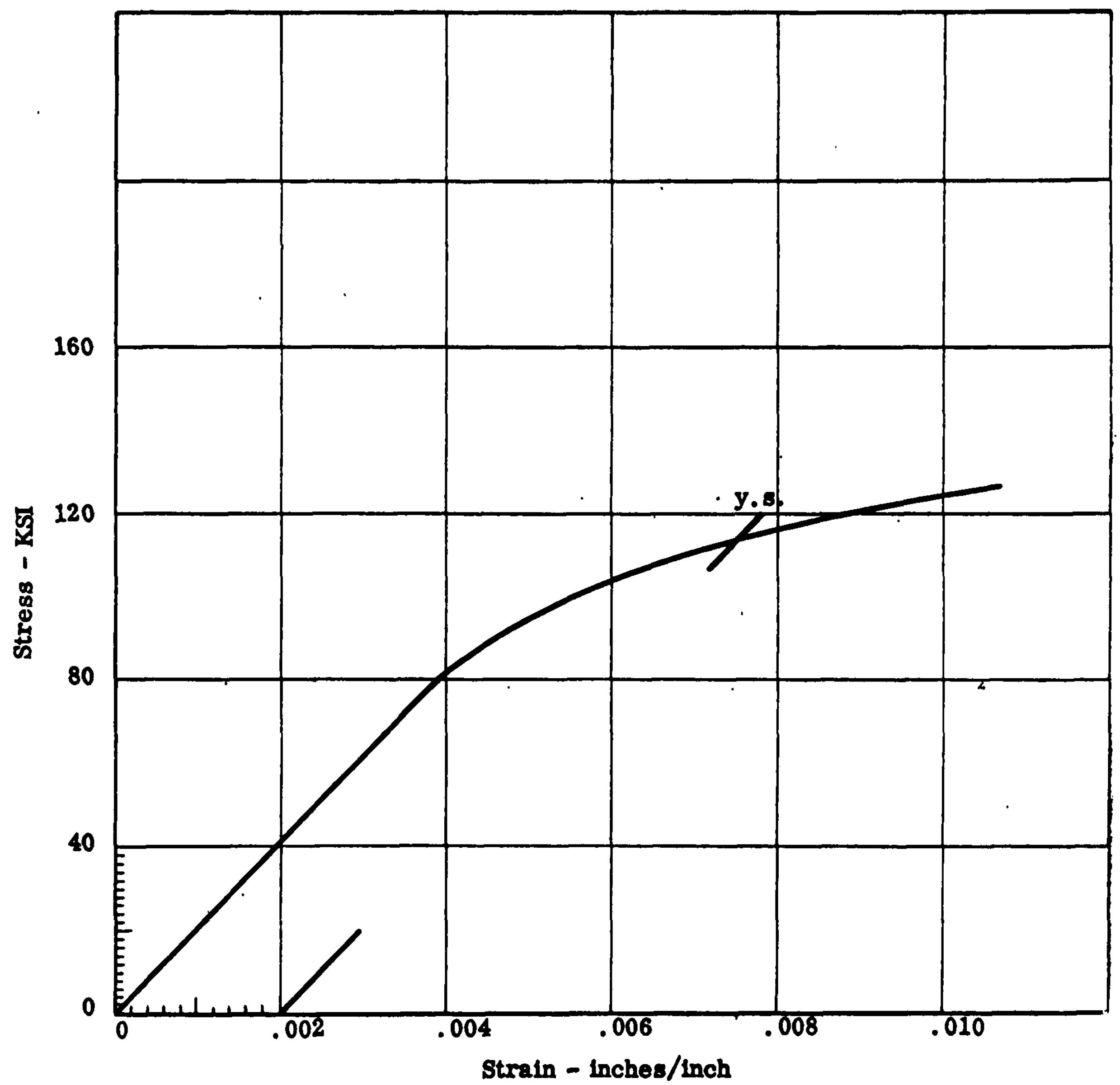
Stress vs. Strain
Specimen 2B
At 600°F - Half Hour Soak



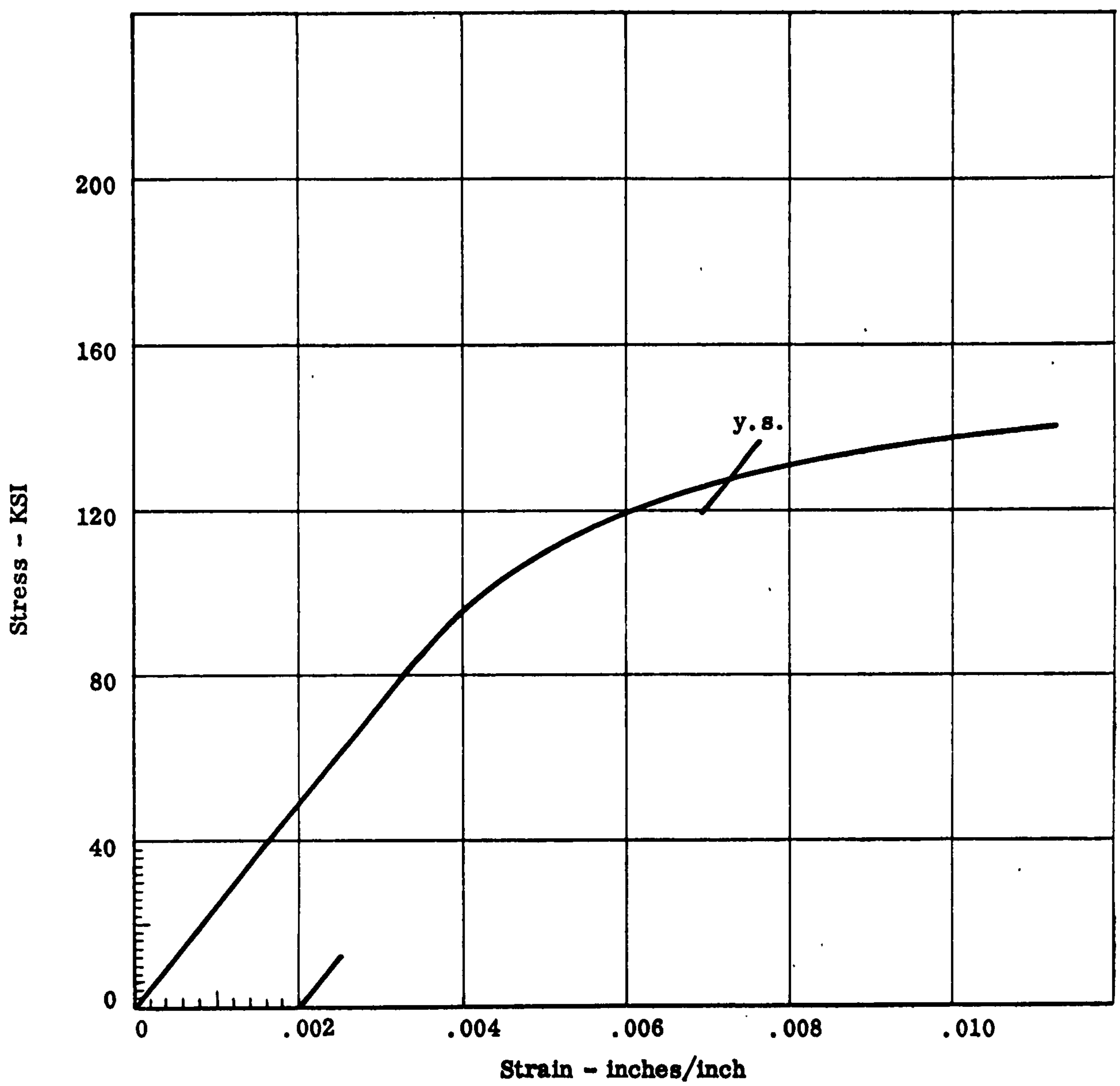
Stress vs. Strain
Specimen 4A
At 800°F - Half Hour Soak



Stress vs Strain
Specimen 4B
At 800°F - Half Hour Soak



Stress vs Strain
Specimen 6A
At 1000°F - Half Hour Soak



Stress vs Strain
Specimen 6B
At 1000°F - Half Hour Soak

MECHANICAL PROPERTIES OF 5Cr-Mo-V STEEL

MATERIAL IDENTIFICATION (COML.)	MATERIAL STATUS
Halcomb 218 and Thermold "A"	Semi-Production
HEAT OR BATCH NUMBER	**FORM**
Unavailable	Sheet

PROCESSING CONDITION

See below

OBJECT OF TEST	RAC DATA REF.
Determine fatigue properties of material and effect of different pre-test conditioning.	ERMR 3929 dated March 28, 1957

SPECIMEN TYPE

See Pages 6 and 7.

TEST METHOD:

Halcomb 218 and Thermold "A", both representative of the 5 Cr-Mo-V hot work die steels, were tested and compared.

All specimens, after machining, and forming if required, were heat-treated to the 200 ksi level in a salt bath to avoid the possibility of decarburization and the introduction of an added variable in fatigue testing.

Axial tension fatigue data are reported in pages 3 and 4 for stress values of 25, 50, 67 and 80 percent of the room temperature ultimate tensile strength (established by testing of identical prepared material).

Flexure fatigue specimens incorporating bend radii of 2 and 3T on a 90° bend were prepared in accordance with four pre-established conditions.

Condition I

a) Bend in annealed condition
b) Heat-treat to 200 ksi level
c) Vapor blast
d) Fatigue test

Condition II

a) Bend in annealed condition
b) Polish with 180# grit
c) Heat-treat to 200 ksi level
d) Vapor blast
e) Fatigue test

Condition III

a) Bend in annealed condition
b) Heat-treat to 200 ksi level
c) Vapor blast
d) Polish with 180# grit
e) Fatigue test

Condition IV

a) Polish with 180# grit
b) Bend in annealed condition
c) Heat-treat to 200 ksi level
d) Vapor blast
e) Fatigue test

A Krause fatigue machine was modified to accept the flexure fatigue specimen design. A photograph illustrating the test set-up is provided on page 10 . Specimen loading was accomplished by varying the eccentricity of the crank journal with relation to the main drive shaft. Deflections at the upper end of the connecting rod were transmitted to the specimen gage length by a coupling arm connected to the cam-rod small end. The entire specimen with the exception of the reduced section gage length was adequately supported to eliminate extraneous bending. Maximum outer fibre stresses in the reduced section center which was also the center of the bend arc, were calculated by means of the moment area method for a cantilever beam. All flexure testing was conducted at 67 percent UTS in complete reverse bending.

Halcomb 218-Tension Fatigue Avg. Ultimate Strength

Of 208500 psi Used For Fatigue Stress Calculations

Thickness Inches	Width Inches	ARea Inches^2	Test Stress psi	Preload 3.86 lbs. = .001"	Alter-nating Load Lbs.	Cycles	Remarks
.077	.507	.039	166500			27000	Fail
.077	.492	.0379	166500	.179	568	17000	Fail
.077	.521	.0401	140800	.132	621	28000	Fail
.078	.486	.0379	153000	.152	580	23000	Fail
.078	.515	.0400	104200	.119	376	102000	Fail
.078	.508	.0396	104200	.118	373		
.0805	.492	.0394	52100	.0585	185.4	10^7	Run out
.076	.498	.0378	52100	.056	177.2	10^7	Run out
.076	.498	.0378	140800	.152	478.8	70000	Fail

Static Tensile Data

T	W	A	U.L.	U.S.	% Elong 2"
.078	.487	.0380	7900	208000	8.0
.0775	.499	.0389	8120	209000	9.0
.075	.486	.037	7640	206400	-

Fatigue Specimen Configuration

Thermold "A" Tension Fatigue Avg. Ultimate Strength

Of 216,000 psi Used For For Fatigue Stress Calculations

Thickness Inches	Width Inches	Area Inches^2	Test Stress (psi)	Preload 3.86 lbs. =.001 in.	Alternate Load lbs.	Cycles	Remarks
.075	.500	.0375	173000	.198	583.2	18000	Fail
.075	.488	.0366	173000	.194	569.7	17000	Fail
.074	.486	.0364	145000	.161	475.2	60000	Fail
.075	.489	.0367	145000	.162	478.8	39000	Grip Fail
.075	.488	.0366	108000	.120	355.4	218000	Fail
.075	.491	.0368	108000	.121	357.8	10.2×10^6	Run Out
.075	.489	.0367	108000	.121	356	100000	Fail
.075	.486	.0364	108000	.120	353.8	126000	Grip Fail
.075	.498	.0373	108000	.120	355.5	109000	Grip Fail
.075	.489	.0367	145000	.163	478.7	68000	Fail

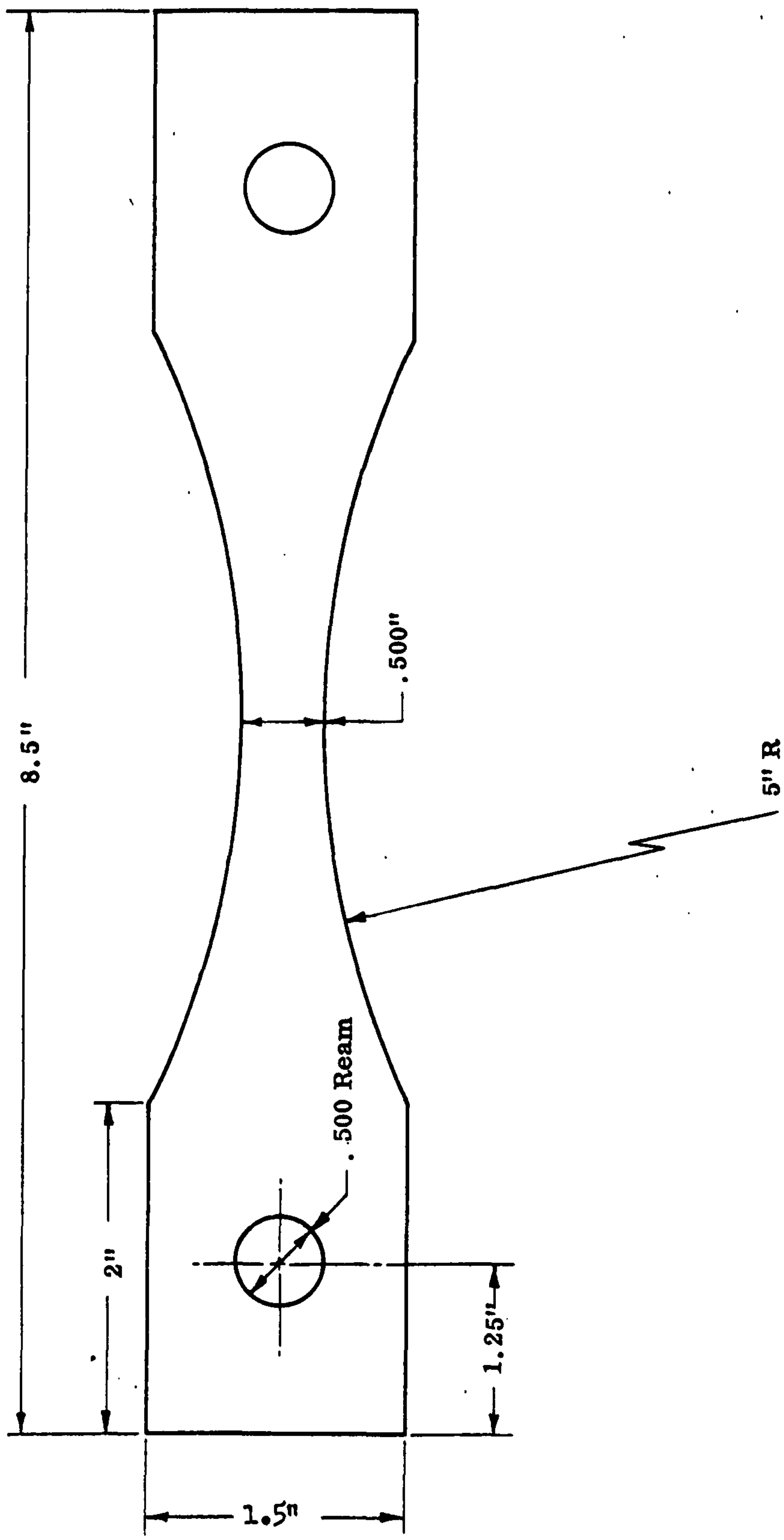
Static Tensile Data

T	W	A	U.L.	U.S.	% Elong. 2"
.075	.495	.0371	7960	215000	8.0
.075	.489	.0367	7960	217000	9.0

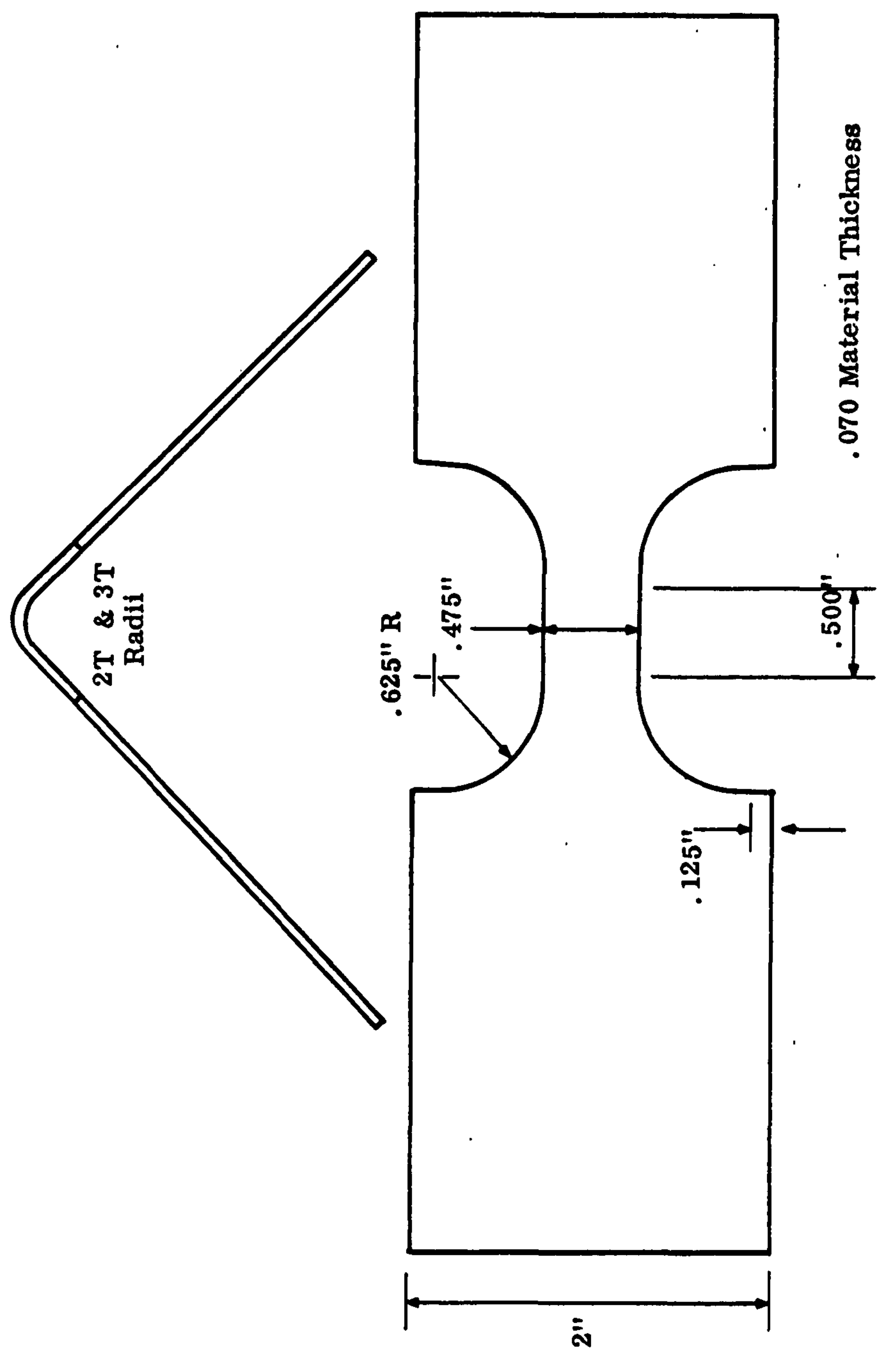
Flexure Fatigue of Bent Sections Halcomb 218 and Thermold A

All Tests Performed At .67 Ultimate Strength

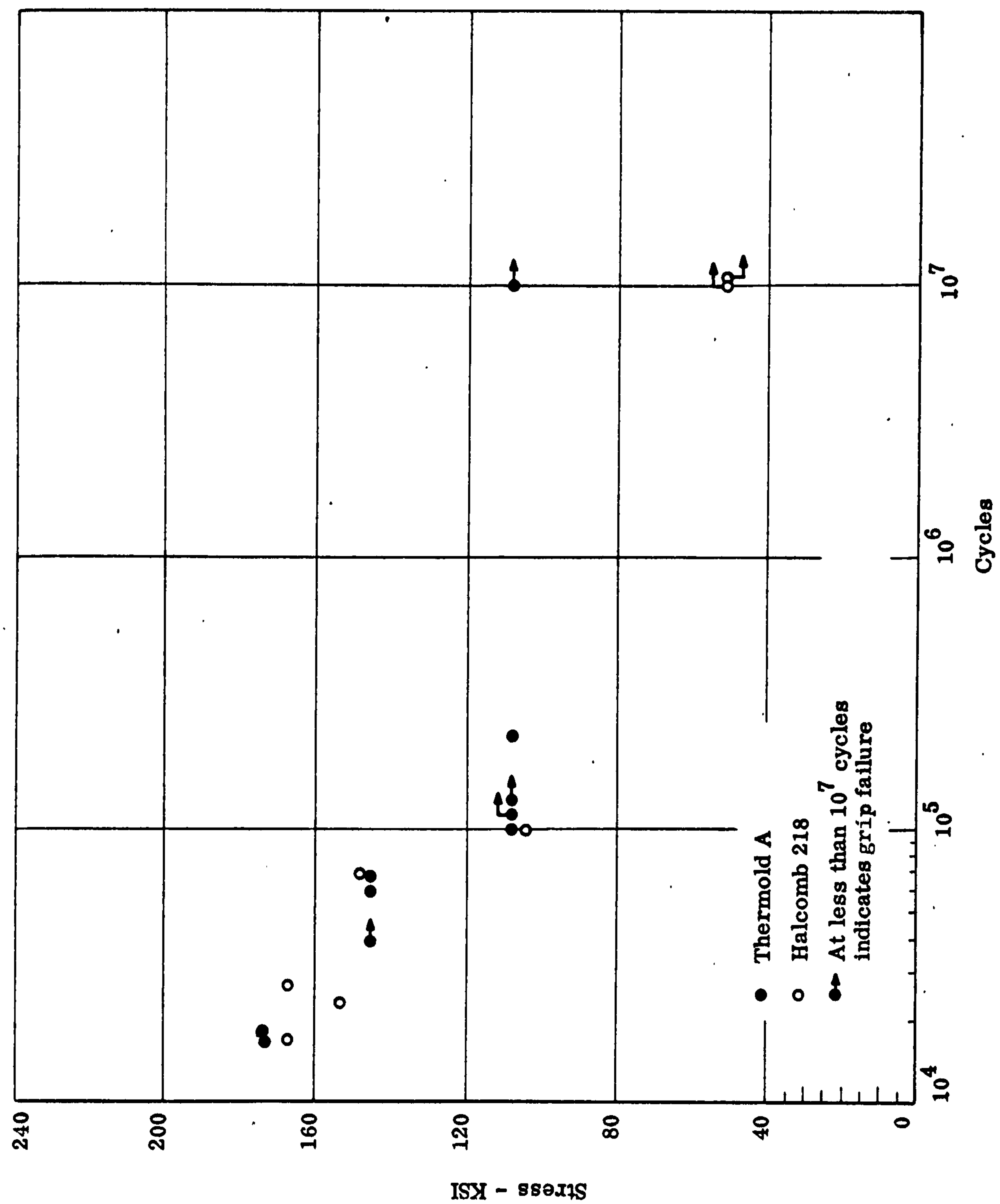
Percent Ultimate Strength	Bend Radius	Material Thickness	Cycles To Failure	Condition
		Halcomb 218		
		Average		
67	2T	.076	6000	I
67	3T	.076	8000	I
67	2T	.076	3900	II
67	3T	.076	10800	II
67	2T	.076	3350	III
67	3T	.076	1100	III
67	2T	.076	4200	IV
67	3T	.076	8200	IV
		Thermold A		
		Average		
67	2T	.075	7100	I
67	3T	.075	8700	I
67	2T	.075	8000	II
67	3T	.075	7150	II
67	2T	.075	3300	III
67	3T	.075	700	III
67	2T	.075	6300	IV
67	3T	.075	10300	IV



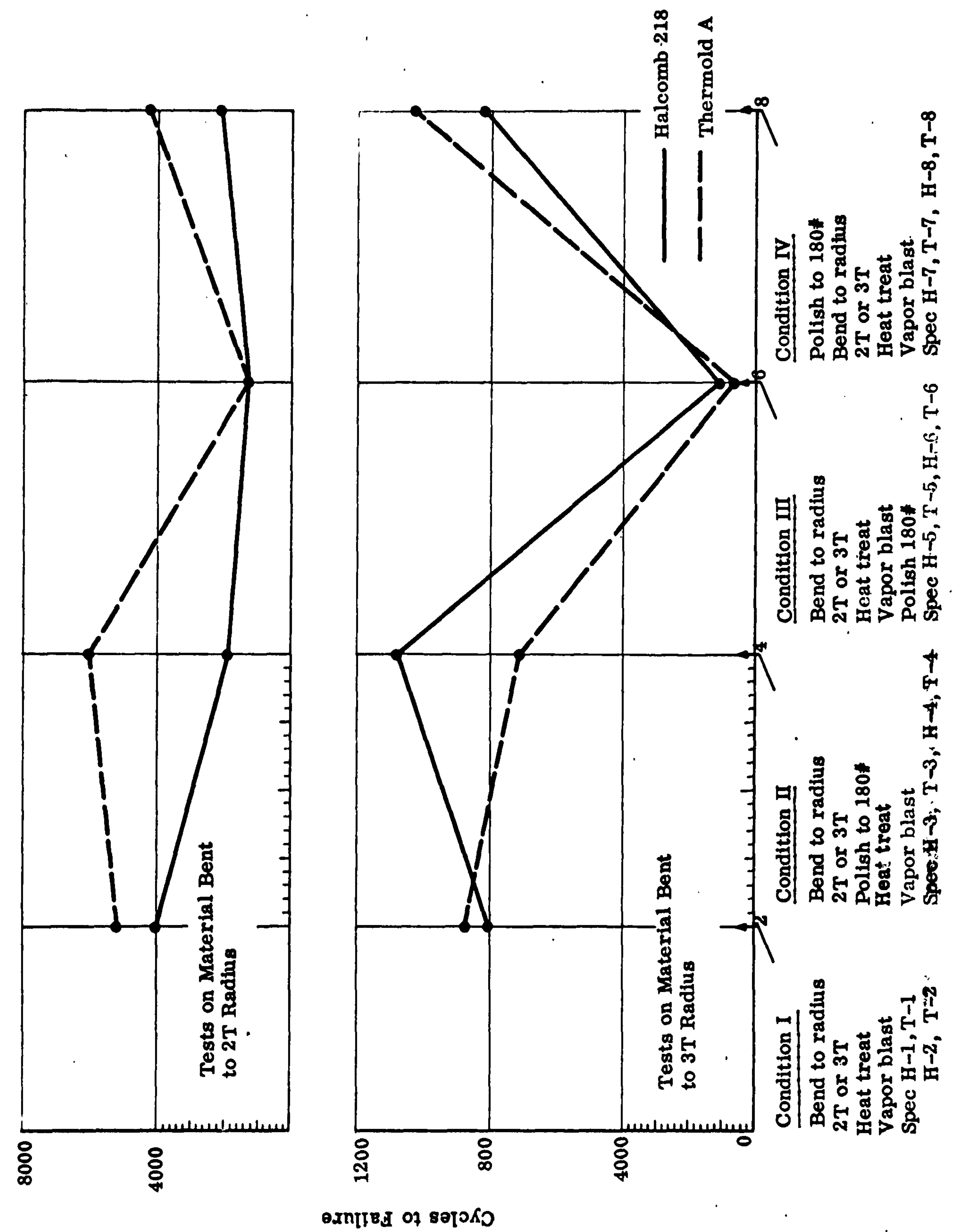
Axial Tension Fatigue Specimen



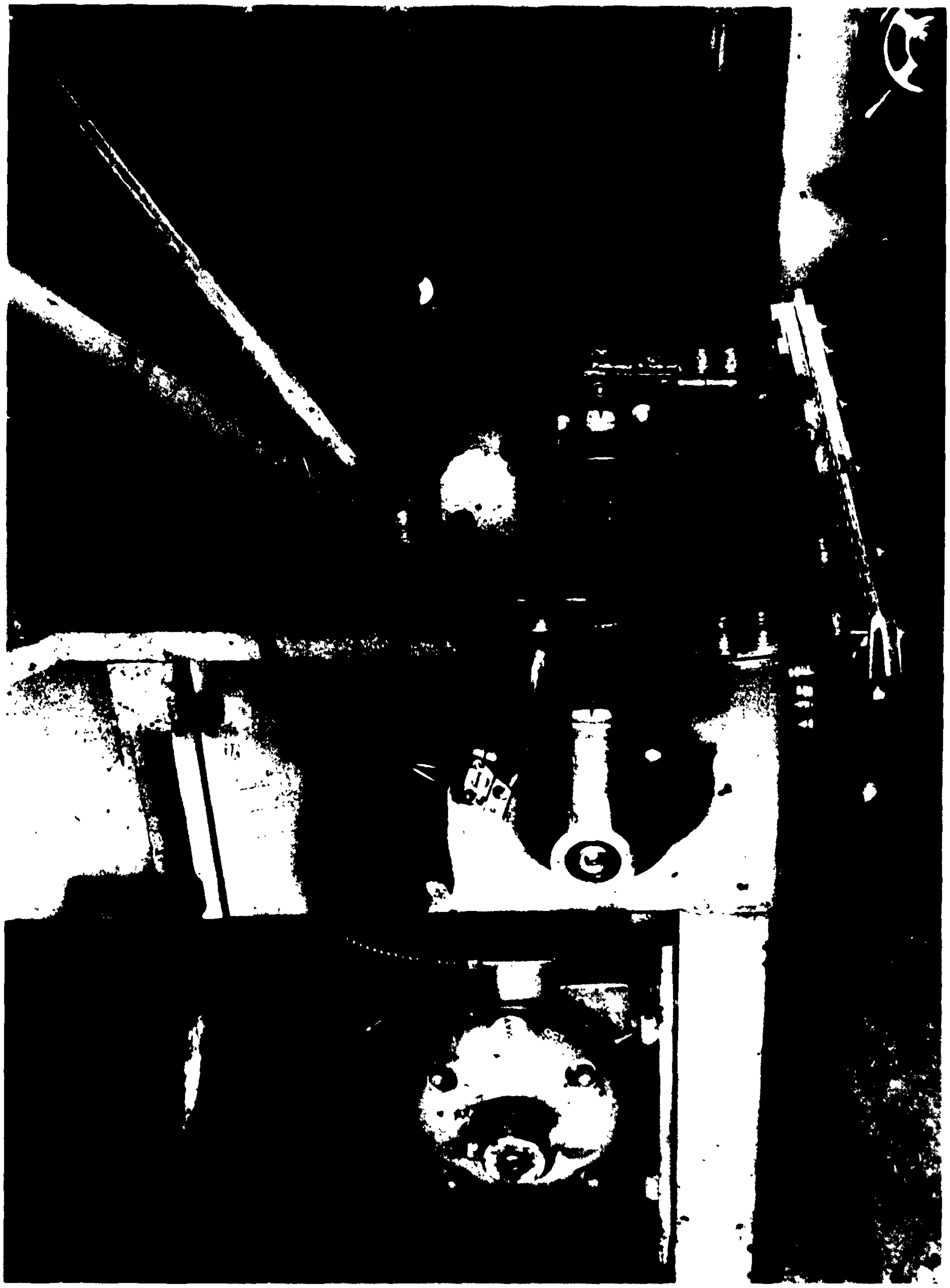
Flexure Fatigue Specimen



Axial Tension Fatigue
Stress Ratio 0.1



Flexture Fatigue (Reverse Bending) - Halcomb 218 & Thermold A



MECHANICAL PROPERTIES OF 17-7PH

MATERIAL IDENTIFICATION (COML.)	MATERIAL STATUS
17-7PH Corrosion Resisting Steel	Production
HEAT OR BATCH NUMBER	**FORM**
See Data Below	Sheet. See Data Below

PROCESSING CONDITION

See Data Below

OBJECT OF TEST	RAC DATA REF.
To determine effect of surface preparation on tensile properties.	RAC unpublished test data, Ref. MRP W.O. 58-127.

SPECIMEN TYPE

Tension - Std. Sheet Metal Per ARTC-13-T, Dated July 1957.

TEST METHOD:

Specimen surfaces were prepared by various processes both before and after heat treatment. In all instances, heat treatment consisted of 1400°F for 90 minutes, cool to 60°F within 1 hour, hold for 1/2 hour at 60°F, 1050°F for 90 minutes, air cool to room temperature. Processes used in preparation of various specimens are itemized below:

Item Number	Process
1	Blank specimen with die.
2	Machine specimen.
3	Deburr edges.
4	Draw file edges.
5	Draw file edges, remove .005" per edge.
6	Draw file edges, remove .010" per edge.
7	Polish edges.
8	Clean and coat with Turco #4367 Scale Inhibitor.
9	Heat Treat, separated.
10	Heat Treat, stacked.
11	Pickle in Nitric-Hydrofluoric acid.
12	Vapor blast.
13	Abrasive finish faces (220A grit paper).
14	Abrasive finish, vibratory barrel.
15	Polish faces.

ROOM TEMPERATURE TENSILE PROPERTIES

Specimen Number	Heat Number	Gage (Inches)	Processing	Tensile Yield Strength (PSI)	Ultimate Tensile Strength (PSI)	Elongation in 2" (%)
A10T-1	880258	.010	Items 2,3,8,9,12,7	162,000	195,000	6.0
-2	"	"		169,000	196,000	7.5
-4	"	"		184,000	203,000	5.5
A10T-6	"	"	Items 2,3,7,8,9,12,7	161,000	182,000	6.0
-7	"	"		166,000	194,000	6.5
-8	"	"		157,000	186,000	7.0
A10T-9	"	"	Items 2,3,4,7,8,9,12, 7	170,000	192,000	7.5
-10	"	"		176,000	198,000	6.0
-11	"	"		163,000	182,000	5.5
A10T-13	"	"	Items 8,9,1,12	173,000	189,000	4.0
-14	"	"		178,000	192,000	3.0
-15	"	"		174,000	190,000	4.0
-16	"	"		176,000	191,000	3.0
A10T-17	"	"	Items 8,9,1,11	156,000	166,000	2.0
-18	"	"		161,000	168,000	2.0
-19	"	"		151,000	162,000	2.0
A10T-21	"	"	Items 8,9,1,12,7	174,000	193,000	6.0
-22	"	"		181,000	200,000	6.5
-23	"	"		177,000	193,000	6.0
A10T-25	"	"	Items 1,4,7,8,9,12	187,000	201,000	5.5
-26	"	"		171,000	188,000	6.0
-27	"	"		175,000	194,000	5.5
A10T-29	"	"	Items 1,8,9,12,7	180,000	203,000	6.5
-30	"	"		177,000	199,000	8.0
-31	"	"		167,000	192,000	8.0
-32	"	"		182,000	199,000	6.0
A10T-28	"	"	Items 1,4,7,8,9,12, 7,15	173,000	192,000	8.0
-33	"	"		177,000	195,000	6.0
-34	"	"		169,000	192,000	5.0
-35	"	"		180,000	202,000	6.0
-36	"	"		173,000	191,000	6.0
-48	"	"		186,000	205,000	7.0
A10T-38	"	"	Items 1,4,7,8,9,, 7,15	182,000	199,000	5.0
-39	"	"		169,000	190,000	7.0
-40	"	"		183,000	199,000	6.5
-45	"	"		189,000	206,000	5.0
-46	"	"		185,000	199,000	5.0
-58	"	"		178,000	193,000	5.0
-60	"	"		172,000	190,000	5.0

ROOM TEMPERATURE TENSILE PROPERTIES

Specimen Number	Heat Number	Gage (Inches)	Processing	Tensile Yield Strength (PSI)	Ultimate Tensile Strength (PSI)	Elongation in 2" (%)
A10T-41	880258	.010	Items 1,7,8,9,12	183,000	198,000	6.0
-42	"	"		172,000	190,000	6.5
-43	"	"		174,000	192,000	7.5
-44	"	"		175,000	194,000	7.0
A10T-49	"	"	Items 1,4,7,8,9	168,000	188,000	7.5
-50	"	"		171,000	188,000	7.5
-51	"	"		171,000	188,000	7.5
-52	"	"		141,000	177,000	7.0
A10T-53	"	"	Items 1,4,7,8,9,11	148,000	168,000	6.0
-54	"	"		152,000	169,000	7.0
-55	"	"		156,000	172,000	6.0
A10T-56	"	"	Items 1,4,7,8,9,11 7,15	166,000	192,000	6.5
-57	"	"		154,000	188,000	5.5
A10T-61	"	"	Items 1,4,7,8,9,13, 7	177,000	193,000	5.5
-62	"	"		168,000	190,000	6.0
-63	"	"		176,000	192,000	5.5
A10T-64	"	"	Items 1,4,7,8,9,13, 7,15	179,000	196,000	6.0
-66	"	"		185,000	198,000	5.0
-67	"	"		173,000	191,000	6.5
A10T-81	"	"	Items 8,9,1,12,7,15	176,000	192,000	5.5
-83	"	"		181,000	198,000	7.5
-84	"	"		187,000	202,000	6.0
A10T-85	"	"	Items 8,9,1,11,7	160,000	170,000	3.0
-86	"	"		161,000	171,000	3.0
-87	"	"		159,000	172,000	4.5
-88	"	"		159,000	171,000	5.5
A10T-91	"	"	Items 8,9,1	170,000	184,000	3.0
-92	"	"		171,000	185,000	3.0
A10T-97	"	"	Items 1,8,9,5,12,7	175,000	210,000	5.5
-98	"	"		175,000	205,000	6.0
-99	"	"		183,000	204,000	6.75
A10T-101	"	"	Items 1,8,9,6,12,7	185,000	206,000	6.25
-102	"	"		181,000	200,000	6.75
-103	"	"		179,000	198,000	6.5

ROOM TEMPERATURE TENSILE PROPERTIES

Specimen Number	Heat Number	Gage (Inches)	Processing	Tensile Yield Strength (PSI)	Ultimate Tensile Strength (PSI)	Elongation in 2" (%)
A10T-105	880258	.010	Items 1,8,9,7	186,000	199,000	6.0
-106	"	"		190,000	200,000	5.5
-107	"	"		182,000	196,000	6.5
-108	"	"		182,000	196,000	6.5
A10T-109	"	"	Items 1,5,8,9,12,7	181,000	197,000	6.0
-110	"	"		197,000	210,000	6.0
-111	"	"		190,000	207,000	5.0
A10T-113	"	"	Items 1,6,8,9,12,7	191,000	204,000	5.5
-114	"	"		187,000	198,000	6.0
-115	"	"		184,000	198,000	5.0
-116	"	"		177,000	196,000	6.0
A10T-117	"	"	Items 1,8,9,11,7	175,000	194,000	7.0
-118	"	"		174,000	192,000	7.0
-119	"	"		174,000	192,000	7.0
-120	"	"		162,000	191,000	7.75
A10T-133	"	"	Items 2,8,9,12,7	177,000	192,000	6.5
-134	"	"		171,000	191,000	6.0
-135	"	"		169,000	188,000	6.0
-136	"	"		177,000	192,000	5.5
A10T-137	"	"	Items 2,8,9,5,12,7	176,000	191,000	6.0
-138	"	"		177,000	192,000	6.0
-139	"	"		169,000	193,000	6.5
-140	"	"		181,000	193,000	5.0
A10T-141	"	"	Items 2,8,9,6,12,7	175,000	192,000	6.5
-142	"	"		178,000	194,000	5.25
-143	"	"		178,000	196,000	7.25
-144	"	"		176,000	191,000	5.5
A10T-145	"	"	Items 2,8,9,7	184,000	194,000	5.5
-146	"	"		185,000	194,000	5.5
-147	"	"		185,000	196,000	5.0
-148	"	"		187,000	198,000	5.0
A10T-149	"	"	Items 2,5,8,9,12,7	184,000	198,000	5.5
-150	"	"		184,000	199,000	6.0
-151	"	"		185,000	199,000	5.5
-152	"	"		183,000	200,000	5.5
A10T-153	"	"	Items 2,6,8,9,12,7	187,000	206,000	7.5
-154	"	"		194,000	210,000	6.5
-155	"	"		188,000	209,000	5.0
-156	"	"		197,000	218,000	6.0

ROOM TEMPERATURE TENSILE PROPERTIES

Specimen Number	Heat Number	Gage (Inches)	Processing	Tensile Yield Strength (PSI)	Ultimate Tensile Strength (PSI)	Elongation in 2" (%)
A10T-157	880258	.010	Items 2,8,9,11,7	183,000	196,000	5.5
-158	"	"		182,000	195,000	7.0
-159	"	"		188,000	197,000	4.25
-160	"	"		188,000	199,000	5.0
A10T-161	"	"	Items 2,10,12,7	239,000	249,000	5.5
-162	"	"		189,000	206,000	6.0
-163	"	"		190,000	205,000	4.5
-164	"	"		208,000	227,000	6.0
A10T-165	"	"	Items 2,10,7	185,000	196,000	6.0
-166	"	"		183,000	196,000	6.0
-167	"	"		185,000	195,000	2.0
-168	"	"		185,000	197,000	5.5
A10T-169	"	"	Items 8,9,1,12,7	197,000	211,000	6.5
-170	"	"		197,000	210,000	8.0
-171	"	"		209,000	220,000	6.0
A10T-173	"	"	Items 8,9,1,5,12,7	197,000	208,000	5.5
-174	"	"		193,000	207,000	6.0
-175	"	"		191,000	206,000	5.75
-176	"	"		187,000	204,000	5.25
A10T-177	"	"	Items 8,9,1,6,12,7	188,000	204,000	5.5
-178	"	"		182,000	199,000	7.75
-179	"	"		180,000	198,000	6.75
-180	"	"		175,000	193,000	6.75
A10T-181	"	"	Items 8,9,7	184,000	196,000	6.0
-182	"	"		177,000	193,000	6.0
-183	"	"		179,000	193,000	6.5
-184	"	"		181,000	193,000	5.5
A10T-185	"	"	Items 8,9,2,12,7	179,000	194,000	6.25
-186	"	"		180,000	196,000	6.25
-187	"	"		195,000	209,000	3.0
-188	"	"		184,000	204,000	5.0
A10T-189	"	"	Items 8,9,2,5,12,7	189,000	203,000	5.5
-190	"	"		191,000	205,000	7.5
-191	"	"		189,000	202,000	6.0
-192	"	"		185,000	200,000	7.25
A10T-193	"	"	Items 8,9,2,6,12,7	180,000	197,000	6.0
-194	"	"		182,000	198,000	7.0
-195	"	"		183,000	198,000	6.5
-196	"	"		177,000	195,000	6.5

ROOM TEMPERATURE TENSILE PROPERTIES

Specimen Number	Heat Number	Gage (Inches)	Processing	Tensile Yield Strength (PSI)	Ultimate Tensile Strength (PSI)	Elongation in 2" (%)
A10T-197	880258	.010	Items 8,9,2,7	180,000	193,000	6.5
-198	"	"		172,000	190,000	6.5
-199	"	"		177,000	191,000	6.5
-200	"	"		175,000	189,000	6.25
A10T-201	"	"	Items 10,2,7	183,000	192,000	4.5
-202	"	"		183,000	190,000	4.0
-203	"	"		180,000	191,000	6.0
-204	"	"		180,000	188,000	5.0
A10T-205	"	"	Items 10,2,12,7	189,000	199,000	4.25
-206	"	"		186,000	198,000	5.0
-207	"	"		188,000	199,000	6.5
-208	"	"		185,000	195,000	6.0
A10T-213	"	"	Items 2,8,9,14,7	196,000	209,000	8.75
-214	"	"		194,000	207,000	6.0
-216	"	"		198,000	211,000	8.0
A10T-217	"	"	Items 8,9,1,14	185,000	198,000	6.25
-218	"	"		175,000	193,000	6.25
-219	"	"		176,000	193,000	6.25
-220	"	"		181,000	196,000	6.5

MECHANICAL PROPERTIES OF INVAR

MATERIAL IDENTIFICATION (COML.)	MATERIAL STATUS
Invar	Production
HEAT OR BATCH NUMBER	**FORM**
Unavailable	Sheet, .010" Gage

PROCESSING CONDITION

See Data Below.

OBJECT OF TEST	RAC DATA REF.
To determine the effect of work hardening and stress relief on mechanical properties.	RAC MRP Report No. 60-116-1 dated March 16, 1961.

SPECIMEN TYPE

Tension - Std. Sheet Metal Per ARTC-13-T, dated July 1957.

TEST METHOD:

Specimen Condition:

A. Specimens A1 through A6: As received (annealed by producer).
B. Specimens B1 through B7: Cold rolled to reduction indicated in data below.
C. Specimens C1 through C6: Cold rolled, followed by thermal treatment as follows:

1. $1525^{\circ}F \pm 25^{\circ}F$ for 30 minutes.
2. Water quench.
3. $600^{\circ}F \pm 10^{\circ}F$ for 1 hour.
4. Air cool.
5. $205^{\circ}F \pm 10^{\circ}F$ for 48 hours.
6. Air cool.

Tensile tests were conducted per ARTC-13-T-1 dated July 1957.

ROOM TEMPERATURE TENSILE PROPERTIES

Spec. No.	Gage (Inches)	Gage Reduction (%)	Grain Direction	Ultimate Tensile Strength (PSI)	Tensile Yield Strength (PSI)	Elongation In 2" (%)
A1	.010	0	Longitudinal	82,700	56,300	27.5
A2	.010	0	Longitudinal	85,800	47,800	28.0
A3	.010	0	Longitudinal	86,000	52,000	24.0
A4	.010	0	Transverse	83,400	49,400	27.5
A5	.010	0	Transverse	81,000	47,600	33.5
A6	.010	0	Transverse	82,000	48,000	24.5

ROOM TEMPERATURE TENSILE PROPERTIES - (Continued)

Spec. No.	Gage (Inches)	Gage Reduction (%)	Grain Direction	Ultimate Tensile Strength (PSI)	Tensile Yield Strength (PSI)	Elongation In 2" (%)
B1	.0075	25	Transverse	107,000	93,000	3.5
B2	.0075	25	Transverse	108,000	103,100	4.0
B3	.0060	40	Transverse	130,400	126,100	3.0
B4	.0059	41	Transverse	120,800	117,400	2.0
B5	.0056	44	Transverse	137,100	136,400	2.5
B6	.0045	55	Transverse	105,400	103,100	1.5
B7	.0034	66	Transverse	122,800	107,800	1.0
C1	.0072	28	Transverse	69,000	41,800	27.5
C2	.0068	32	Transverse	67,600	40,600	17.0
C3	.0053	47	Transverse	65,000	40,500	24.0
C4	.0052	48	Transverse	65,100	39,900	21.5
C5	.0042	58	Transverse	59,900	42,500	12.5
C6	.0032	68	Transverse	59,100	43,400	13.0

MECHANICAL PROPERTIES OF AISI 302 STAINLESS STEEL	CODE: 1.AG.6.11.1
	PAGE 1 OF 27

MATERIAL IDENTIFICATION (COML.)	MATERIAL STATUS
302 Stainless	Production
HEAT OR BATCH NUMBER	**FORM**
Unavailable	Sheet

PROCESSING CONDITION

Half hard

OBJECT OF TEST	RAC DATA REF.
Determine spotweld properties	ERMR 13 dated July 23, 1956

SPECIMEN TYPE

See pages 12 and 13.

TEST METHOD: A series of tensile pull-out and tensile shear tests were performed on the 302 stainless material. The results obtained are indicated in the accompanying tables.

The shear specimens, as shown on page 12, were tested on a Baldwin-Emery SR-4 testing machine of 50,000 pounds capacity after allowing the specimens to soak at temperature for 1/2 hour. Ultimate load vs. temperature data was recorded and shown on appropriate accompanying curves.

The oven used to reach and maintain temperatures was a portable two-piece unit which could be placed around the specimen and removed after testing. A chromel-alumel thermocouple and potentiometer was used to measure temperature which was accurate up to $\pm$ 10°F.

Two holes were drilled in the ends of the tensile shear specimens selected for fatigue testing in order to facilitate mounting into a Sontag 10,000 lb. SF-10U fatigue testing machine. The "U" section specimens were attached to the adjustable jig (page 13) and the whole assembly was then mounted on a Sontag 2000 lb. SF-1U fatigue testing machine. The adjustable jig was designed to insure a tight fit-up between the specimen and jig at all times during testing. This tended to prevent scattered results due to excessive vibration during testing. The minimum/maximum ratio used for all fatigue tests was 0.1.

Page 27 is a photograph (mag. = 250X) of a typical as-cast grain structure of half-hard stainless steel.

TEST RESULT SUMMARY

STAINLESS STEEL HALF-HARD

Material Thickness	Average Tensile Pullout - lb.	Average Tensile Shear - lb.		Ratio Tensile Pullout to Tensile Shear
REFERENCE	1	1	2	2
.025-.025	710	1388	1249	.512
.031-.031	780	1937	2033	.403
.040-.040	1030	2477	2598	.418
.050-.050	1745	3455	3304	.506
.062-.062	1980	4099	4440	.485
.078-.078	4150	5927	5250	.703

REFERENCE CODE:

1. Tests by shop process section
2. Tests by engineering research section

ELEVATED TEMPERATURE SHEAR DATA - STAINLESS STEEL 1/2 HARD .078"

Temperature °F	Ult. Load Lbs.	Average
100	5100 5400	5250
200	5300 5200	5250
250	4820	4820
300	4500 5200	4850
350	4440	4440
400	5000 4740	4870
450	4420	4420
500	4340 4480	4410
550	4340	4340
600	4300 4170	4235
650	3840	3840
700	3840 4080	3960
750	3800	3800
800	4000 3800	3900
850	4020	4020
900	3780 4280	4030
950	3900	3900
1000	3820 3800	3810

ELEVATED TEMPERATURE SHEAR DATA - STAINLESS STEEL 1/2 HARD .064"

Temperature °F	Ult. Load Lbs.	Average
RT	4600	4440
	4330	
	4200	
	4600	
	4560	
	4350	
100	4300	4233
	4200	
	4200	
150	4540	4260
	3980	
200	4260	4120
	4000	
	4100	
250	3600	3700
	3800	
300	3920	3507
	3200	
	3400	
350	3300	3450
	3600	
400	3700	3333
	3000	
	3300	
450	3360	3400
	3440	
500	3400	3467
	3540	
	3460	

Temperature °F	Ult. Load Lbs.	Average
550	3380	3307
	3340	
	3200	
600	3460	3283
	3260	
	3130	
650	3140	3173
	3180	
	3200	
700	2900	2957
	3320	
	2650	
750	3100	3027
	3020	
	2960	
800	3260	3027
	2880	
	2940	
850	2600	2800
	2845	
	2955	
900	2500	2660
	2960	
	2620	
950	2455	2788
	2960	
	2950	
1000	2870	2880
	2890	

ELEVATED TEMPERATURE SHEAR DATA - STAINLESS STEEL 1/2 HARD .050"

Temperature °F	Ult. Load Lbs.	Average	Temperature °F	Ult. Load Lbs.	Average
RT	3355 3370 3250 3240	3304	550	2380 2370 2460 2350	2390
100	3190 2920 3140 2970	3055	600	2360 2350 2310 2370	2348
150	2900 2880 2880 2920	2895	650	2500 2310 2230 2170	2403
200	2790 2880 2700 2800	2793	700	2295 2390 2310 2380	2344
250	2690 2750 2600 2680	2680	750	2270 2310 2365 2230	2294
300	2510 2450 2590 2400	2488	800	2210 2140 2290 2250	2223
350	2460 2450 2360 2400	2418	850	2310 2360 2215 2060	2236
400	2500 2390 2280 2300	2368	900	2220 2200 2150 2250	2205
450	2370 2400 2380 2430	2395	950	2085 2020 2410 2440	2239
500	2410 2300 2400 2340	2363	1000	2060 2090 2300 2300	2188

ELEVATED TEMPERATURE SHEAR DATA - STAINLESS STEEL 1/2 HARD .040"

Temperature °F	Ult. Load Lbs.	Average
RT	2500	2598
	2610	
	2630	
	2620	
	2630	
100	2330	2380
	2530	
	2550	
	2250	
	2240	
150	2200	2108
	2160	
	2200	
	2000	
	1980	
200	2040	2072
	2050	
	2100	
	2190	
	1980	
250	2050	1968
	2000	
	2040	
	1900	
	1850	
300	1940	1990
	2100	
	2200	
	1770	
	1940	
350	1930	1852
	1990	
	1930	
	1710	
	1700	

Temperature °F	Ult. Load Lbs.	Average
400	1800	1790
	1880	
	1860	
	1720	
	1710	
450	1780	1773
	1810	
	1860	
	1700	
	1715	
500	1710	1762
	1800	
	1800	
	1750	
	1750	
550	1750	1745
	1700	
	1740	
	1800	
	1730	
	1750	
600	1700	1747
	1770	
	1700	
	1720	
	1790	
	1800	
650	1820	1752
	1740	
	1740	
	1690	
	1780	
	1720	

ELEVATED TEMPERATURE SHEAR DATA - STAINLESS STEEL 1/2 HARD .040"

Temperature °F	Ult. Load Lbs.	Average	Temperature °F	Ult. Load Lbs.	Average
700	1700	1725	900	1790	1488
	1680			1780	
	1740			1650	
	1760			1630	
	1730			1280	
	1740			1000	
750	1620	1560	950	1760	1458
	1640			1680	
	1600			1610	
	1720			1600	
	1560			1220	
	1200			1080	
800	1760	1622	1000	1660	1407
	1750			1610	
	1740			1620	
	1710			1590	
	1210			1020	
	1360			940	
850	1880	1563			
	1900				
	1800				
	1680				
	1320				
	1400				

ELEVATED TEMPERATURE SHEAR DATA - STAINLESS STEEL 1/2 HARD .032"

Temperature °F	Ult. Load Lbs.	Average
RT	2050	2033
	2015	
100	1210	1295
	1380	
150	1185	1213
	1240	
200	1070	1053
	1035	
250	1025	1048
	1070	
300	990	1028
	980	
	1040	
	1100	
350	960	981
	940	
	1025	
	1000	
400	960	962
	955	
	985	
	950	
450	920	1046
	935	
	915	
	1415	
500	1325	1015
	915	
	905	
	915	
550	890	1010
	1380	
	880	
	890	

Temperature °F	Ult. Load Lbs.	Average
600	1315	1248
	945	
	1420	
	1310	
650	1315	1316
	1320	
	1320	
	1310	
700	1370	1345
	1315	
	1350	
	1345	
750	1300	1330
	1310	
	1360	
	1350	
800	1360	1270
	1330	
	1318	
	1270	
850	1250	1296
	1300	
	1345	
	1290	
900	1320	1273
	1255	
	1260	
	1255	
950	1200	1240
	1230	
	1270	
	1260	
1000	1265	1253
	1255	
	1220	
	1270	

ELEVATED TEMPERATURE SHEAR DATA - STAINLESS STEEL 1/2 HARD .025"

Temperature °F	Ult. Load Lbs.	Average
RT	1050 1180 1360 1370 1210 1325	1249
100	1100 1320 1130	1183
150	1000 1320 1060	1126
200	1040 1200 1050	1097
250	980 960 1020	987
300	920 1040 930	963
350	920 990 915 920	936
400	890 920 1040 1020	968
450	870 860 1000 850	895
500	860 880 950 950	910

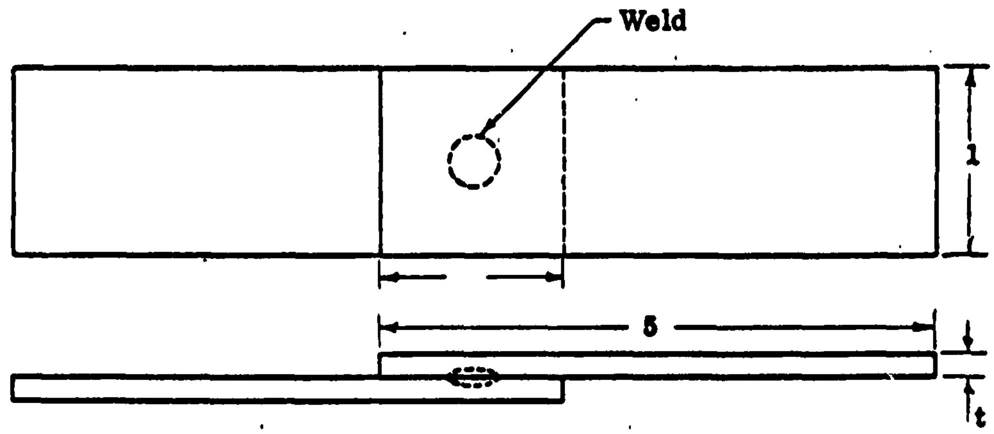
Temperature °F	Ult. Load Lbs.	Average
550	1000 990 940 960	973
600	965 970 890 820	899
650	950 940 920 875	921
700	885 880 850 840	864
750	830 830 780 800	810
800	935 935 825 930	904
850	890 890 750 810	835
900	830 820 810 800	815
950	750 750 760 750	753
1000	680 700 790 785	739

TENSILE SHEAR FATIGUE TEST 1/2 HARD STAINLESS STEEL

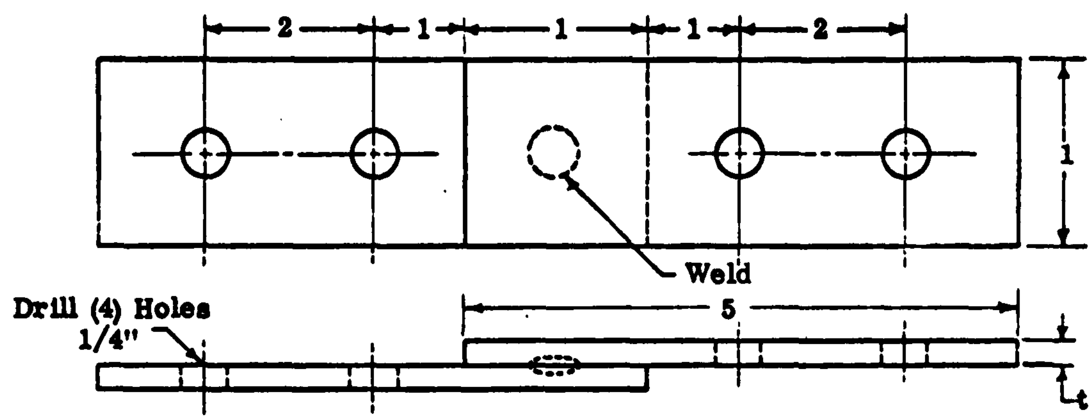
Sheet	Max. Lbs.	% Max.	Load Lbs.	Cycles
.032"	1937	90	1743.0	0
		70	1355.9	1000
		50	968.5	2000
		30	581.1	7000
		15	290.6	32,000
		10	193.7	314,000
.040"	2477	90	2229.3	0
		70	1733.9	1000
		50	1238.5	4000
		30	743.1	7000
		15	371.55	89,000
		10	247.7	315,000

PULL OUT FATIGUE TESTS 1/2 HARD STAINLESS STEEL

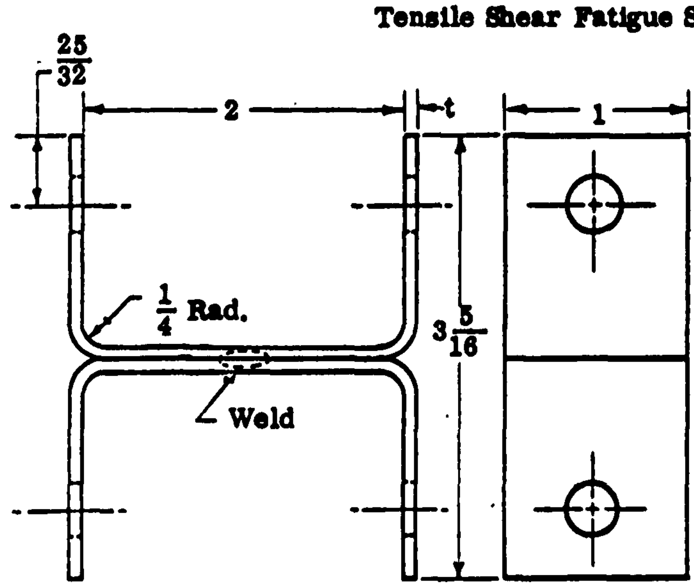
Sheet	Max. Lbs.	% Max.	Load Lbs.	Cycles	
.025"	710	90	639.0	0	
		70	447.0	0	
		50	355.0	0	
		30	213.0	2,000	
		15	100.0	19,000	
		10	71.0	64,000	
		5	35.5	2,537,000	(No Fracture)
.032"	780	90	702.0	0	
		70	546.0	1000	
		50	390.0	4000	
		30	234.0	20,000	
		15	117.0	164,000	
		10	78.0	2,000,000	(No Fracture)
.040"	1030	70	721.0	0	
		50	515.0	1000	
		30	309.0	27,500	
		15	154.5	65,000	
		10	103.0	363,000	
		5	51.5	2,000,000	(No Fracture)
.050"	1745	70	1221.5	0	
		50	872.5	1000	
		30	523.5	2000	
		15	261.75	45,000	
		10	174.5	88,000	
.062"	1980	70	1386.0	0	
		50	990.0	0	
		30	574.0	3000	
		15	287.0	148,000	
		10	198.0	155,000	
		5	99.0	1,076,000	
.078"	4150	50	2075.0	0	
		30	1245.0	2000	
		15	622.5	36,000	
		10	415.0	167,000	



Tensile Shear Specimen



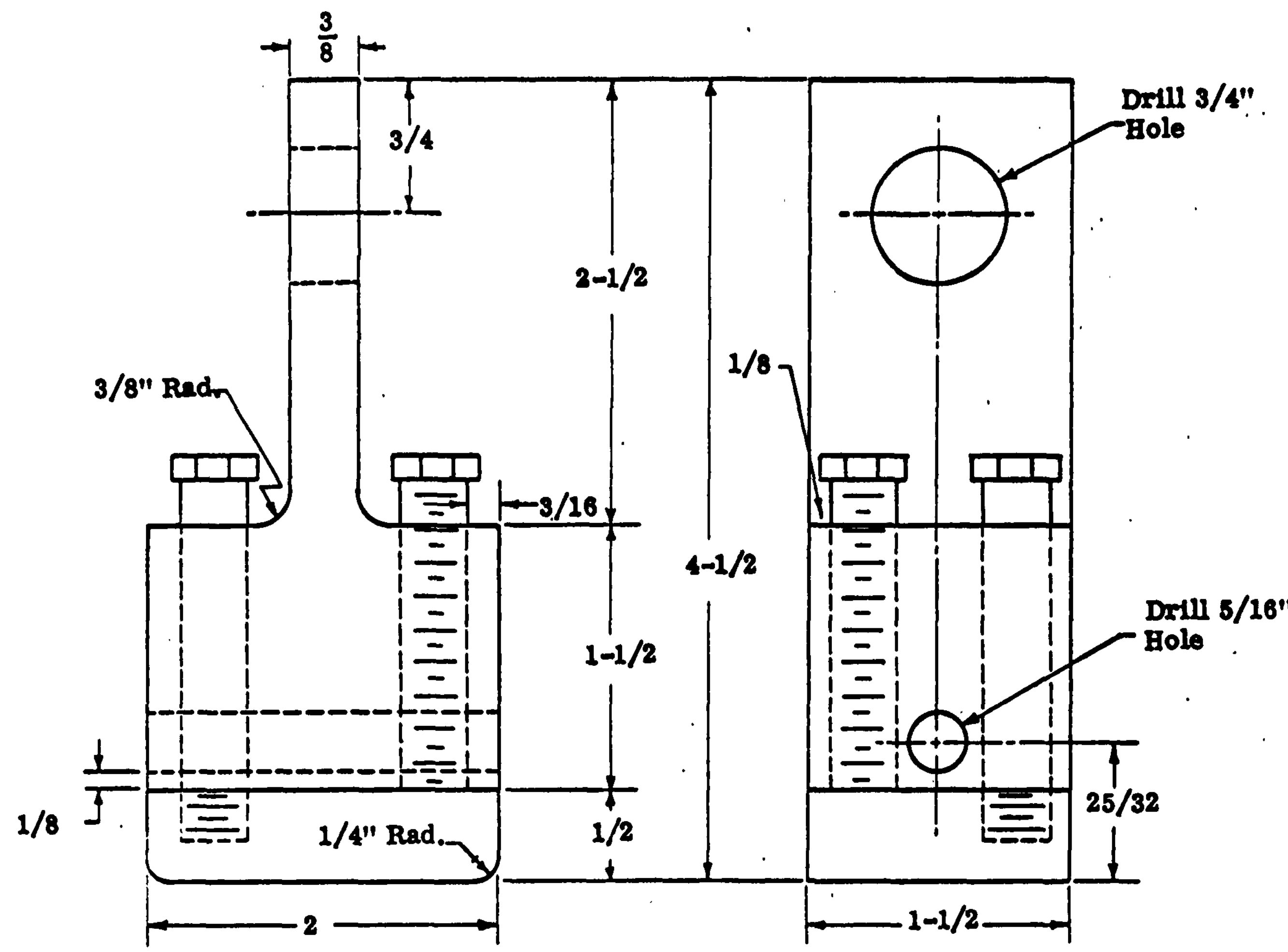
Tensile Shear Fatigue Specimen



U-Type Tensile Pull-Out and Fatigue Specimen

NOTE:

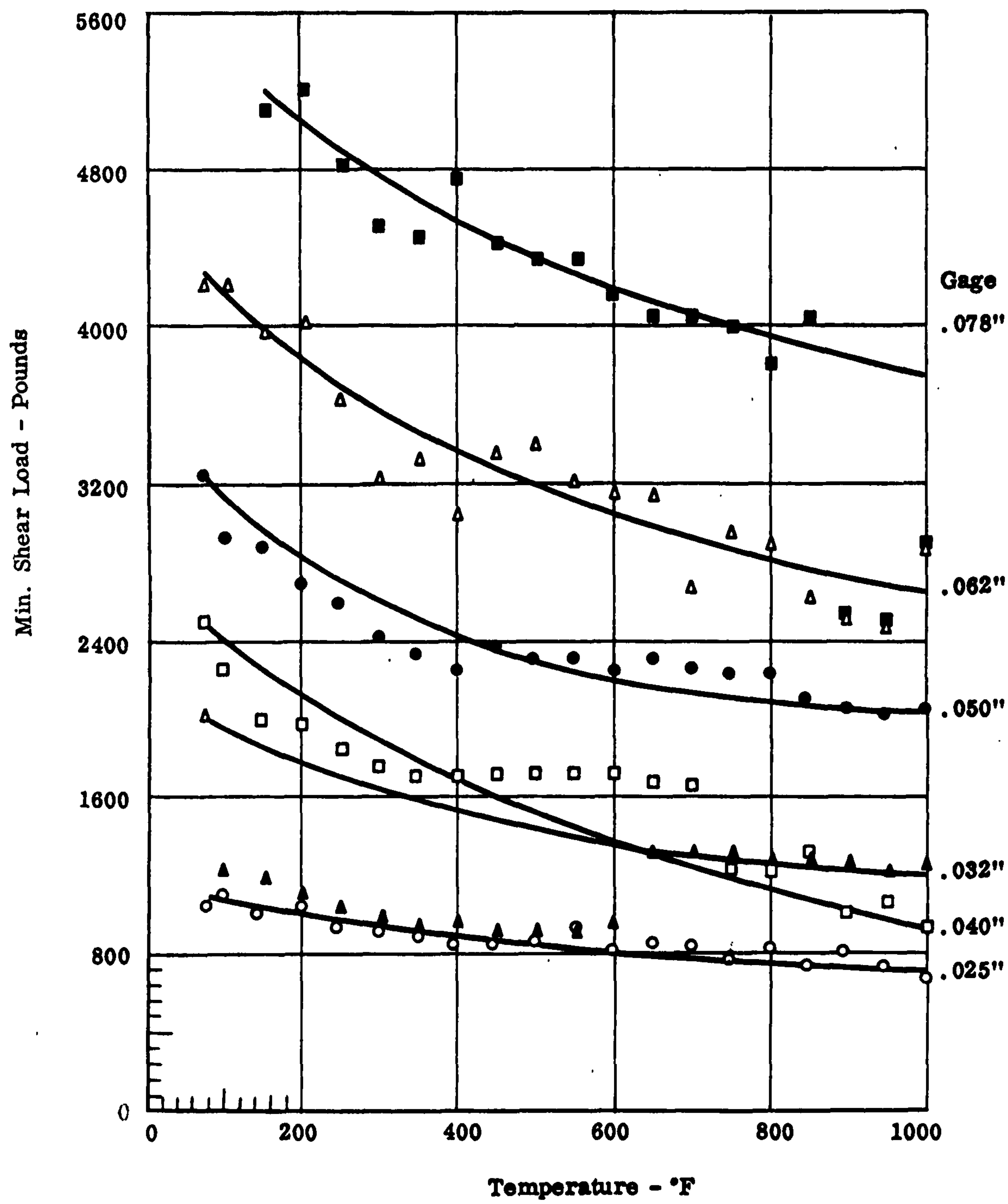
t = .025"
.031"
.040"
.050"
.064"
.078"



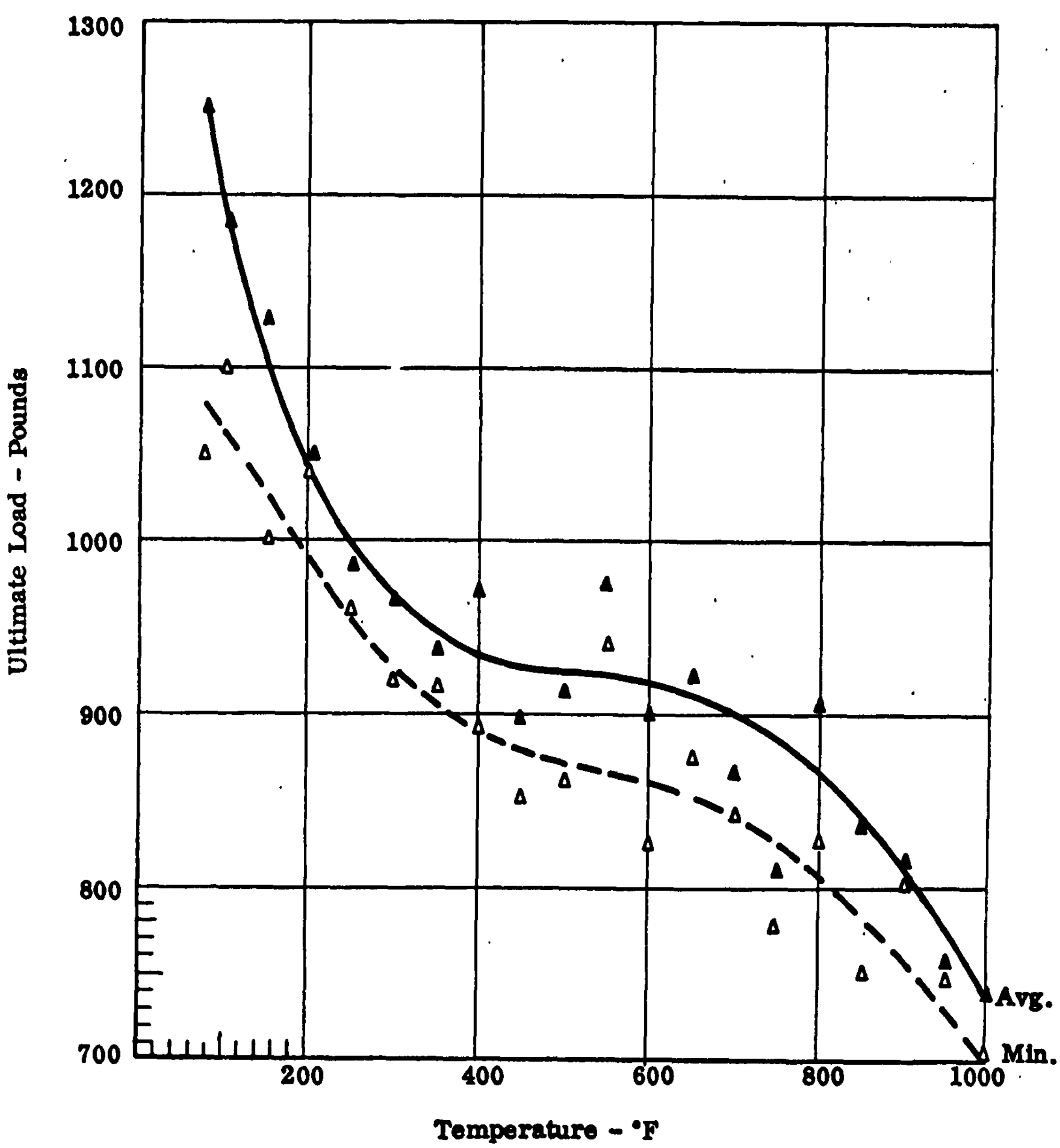
NOTES:

1. Four 3/8-16 NC bolts are used to hold assembly together.
2. Bottom of jig opens 1/4", giving over-all length of 4-3/4".
3. Material = 4340.

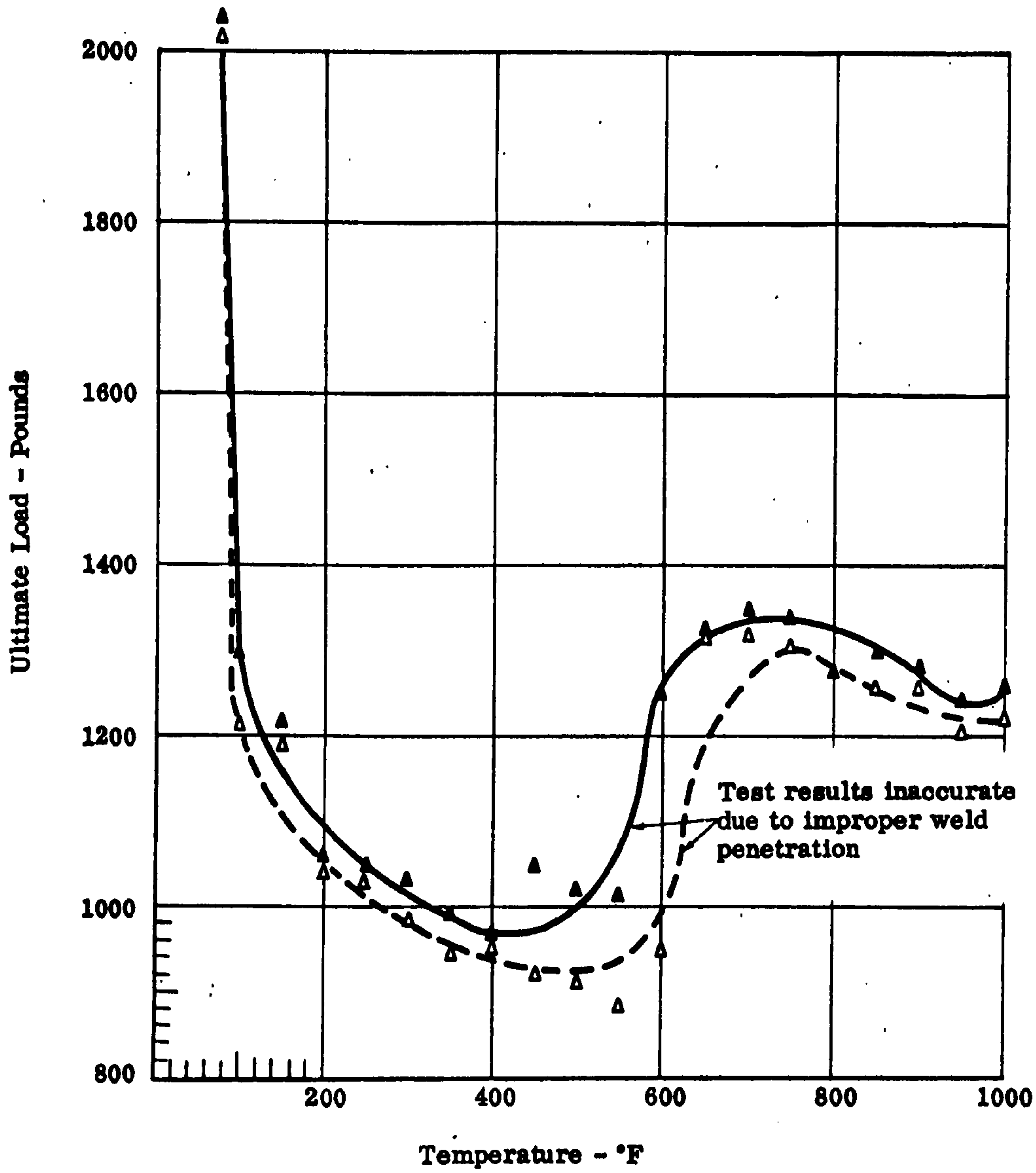
Adjustable U-Section Fatigue Specimen Jig



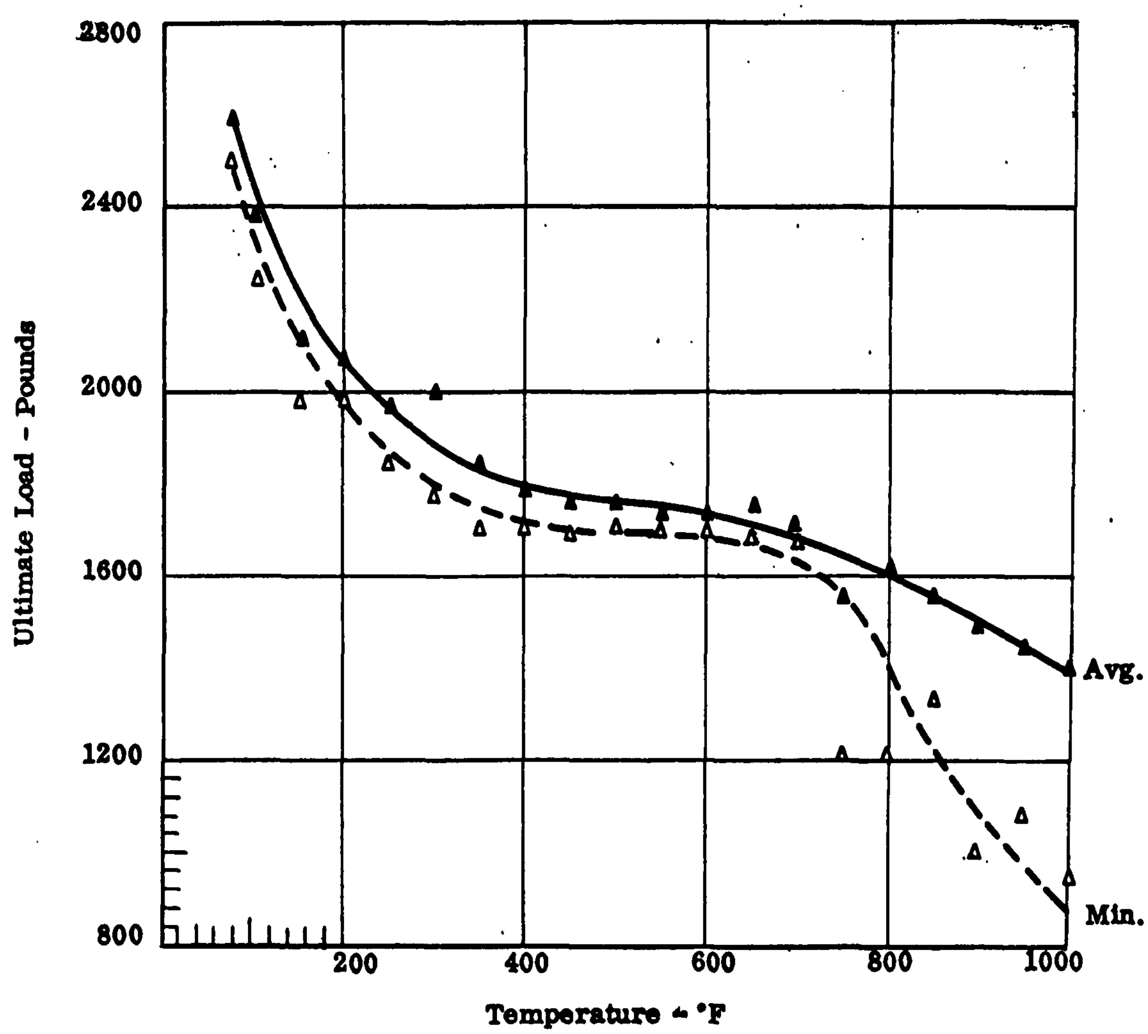
Elevated Temperature Shear Properties of Stainless
Steel Halfhard Spotwelds



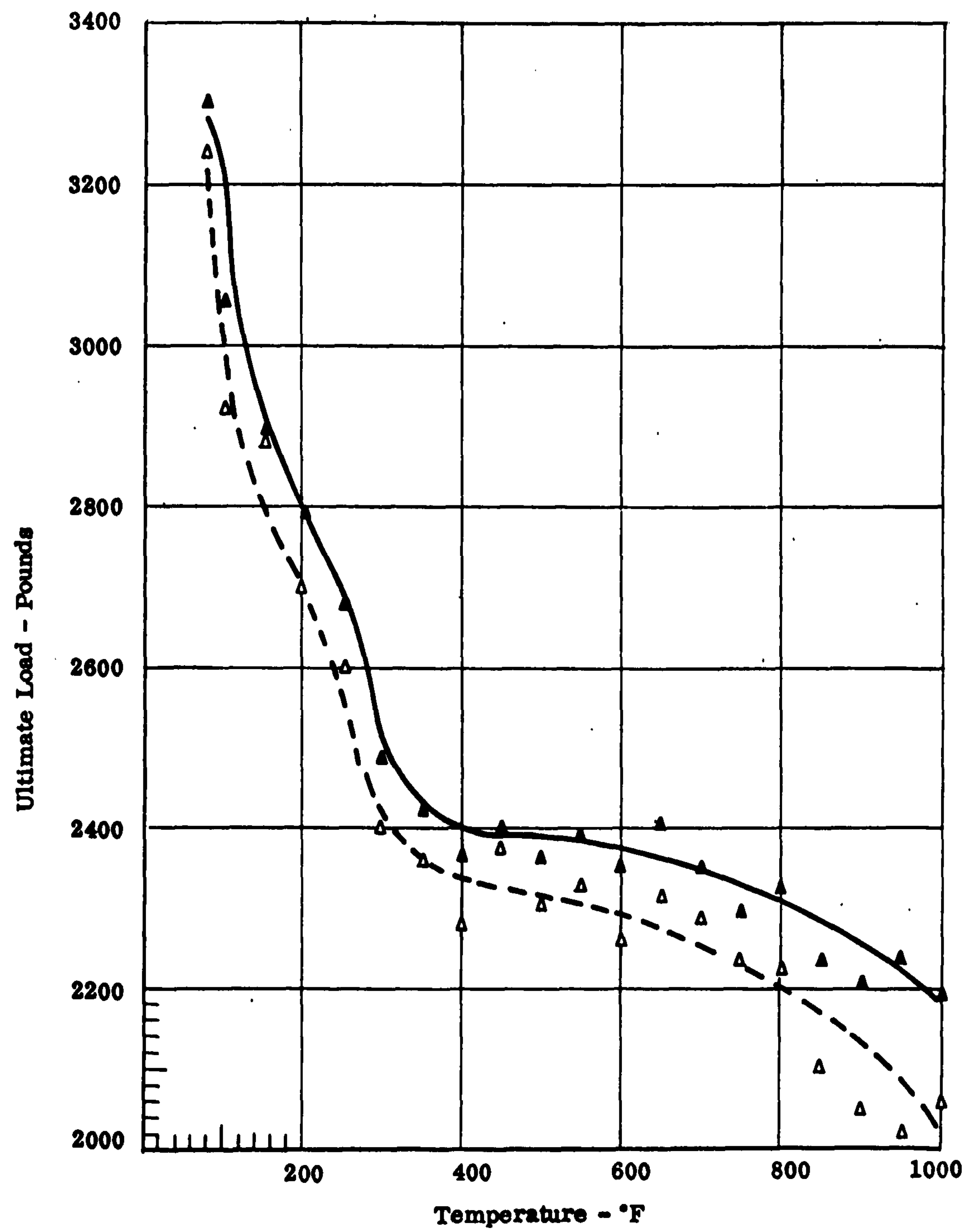
Load vs Temperature Properties - .025 Spot Welded Sheet



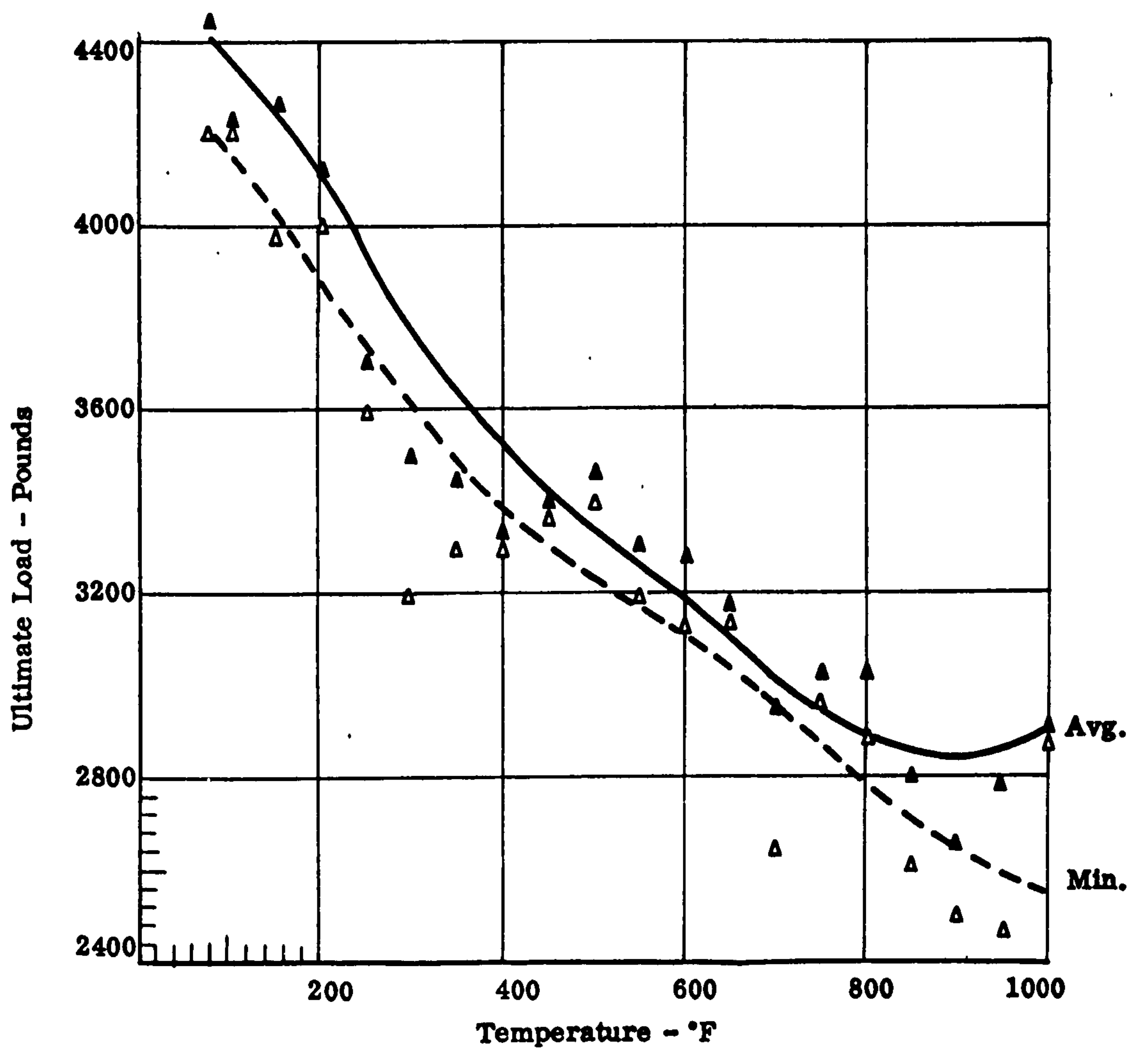
Load vs Temperature Properties - .032 Spot Welded Sheet



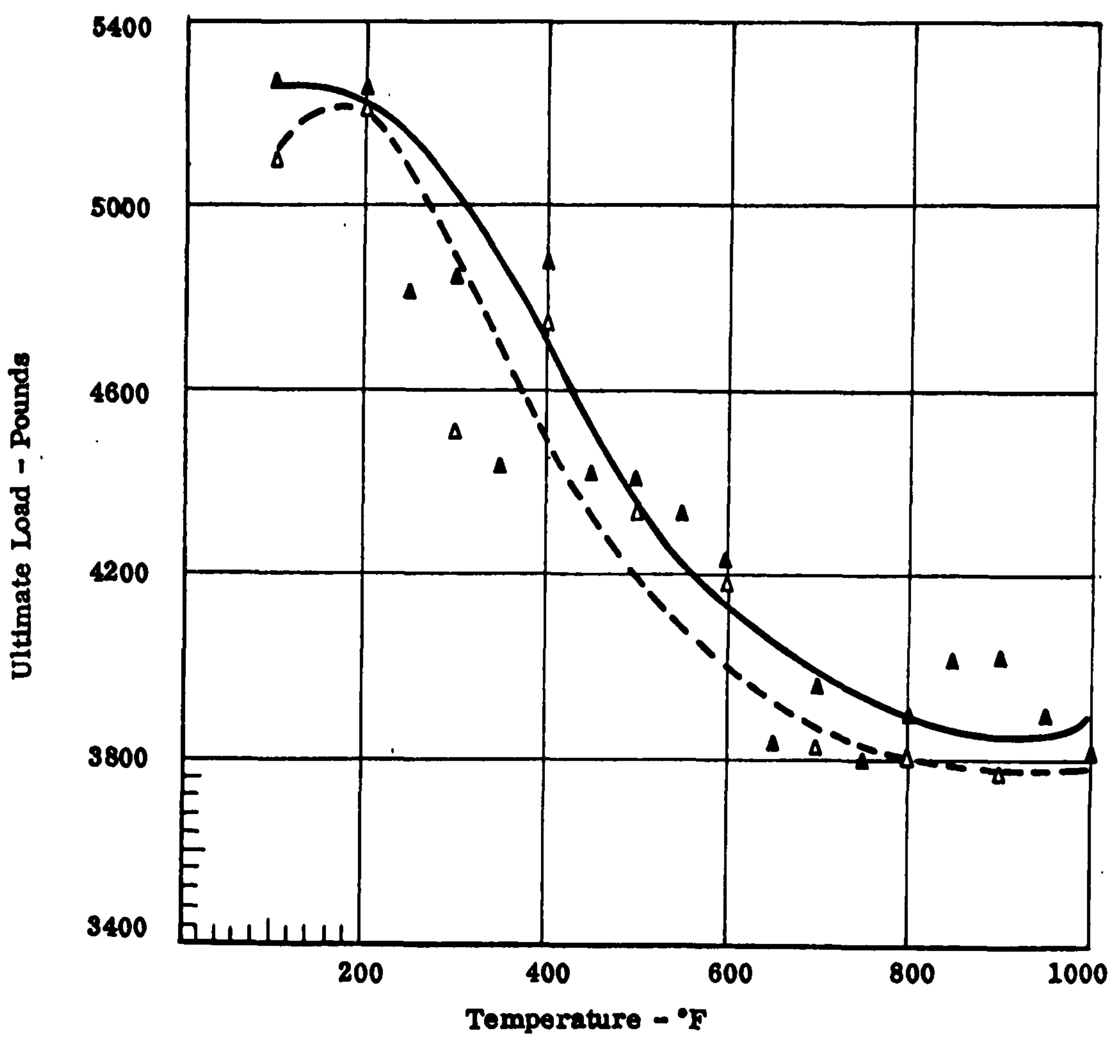
Load vs Temperature Properties - .040 Spot Welded Sheet



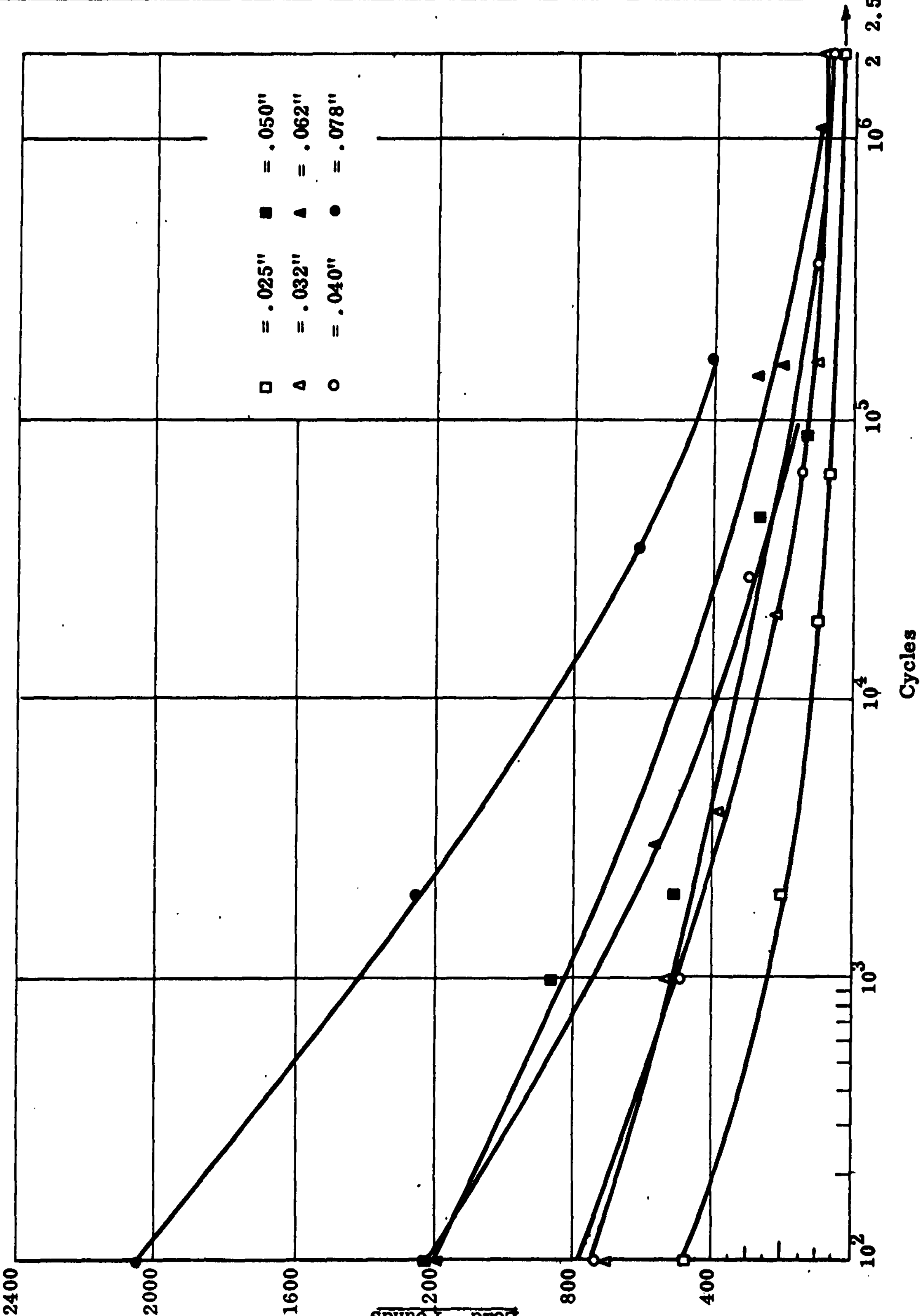
Load vs Temperature Properties - .050 Spot Welded Sheet



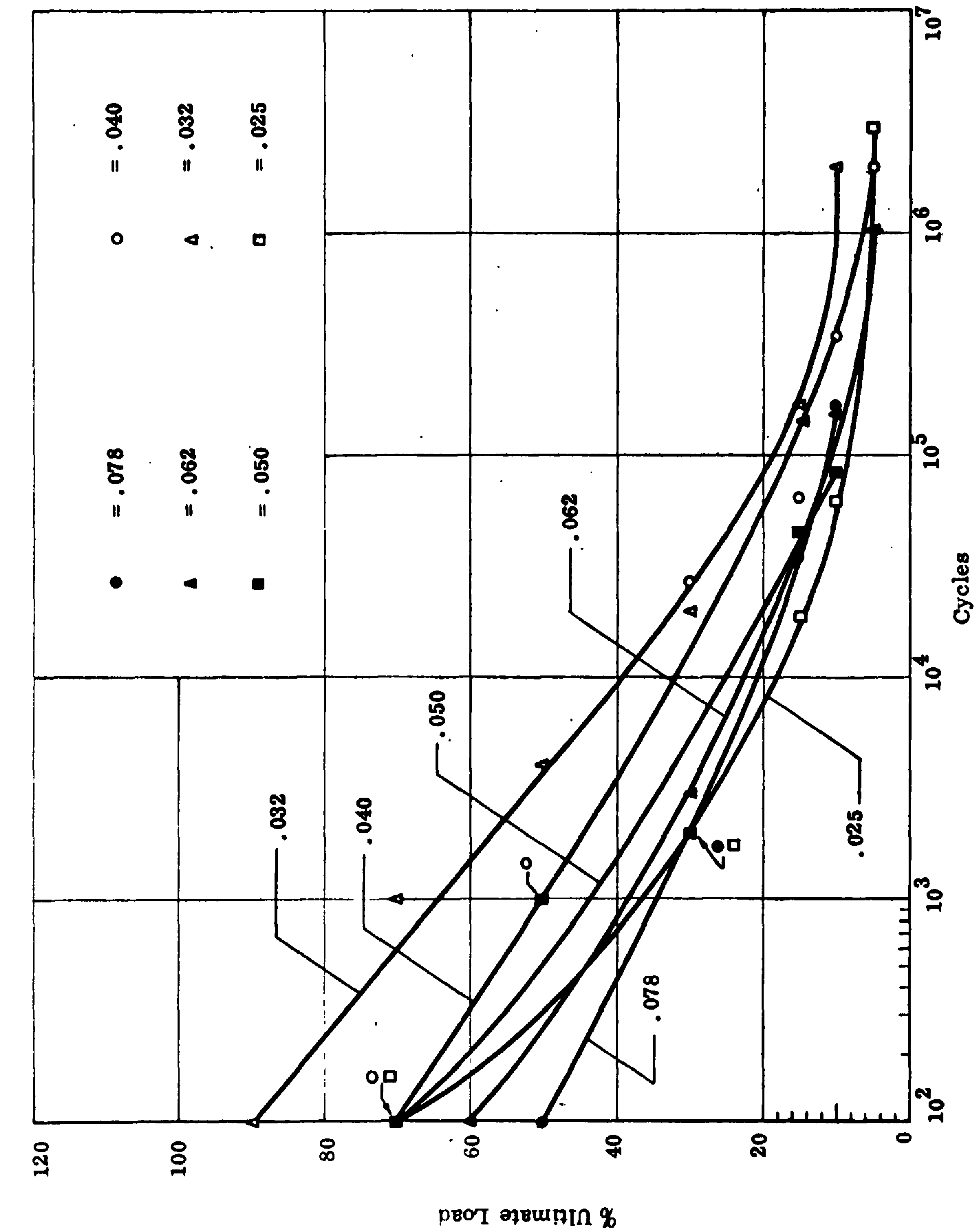
Load vs Temperature Properties - .062 Spot Welded Sheet



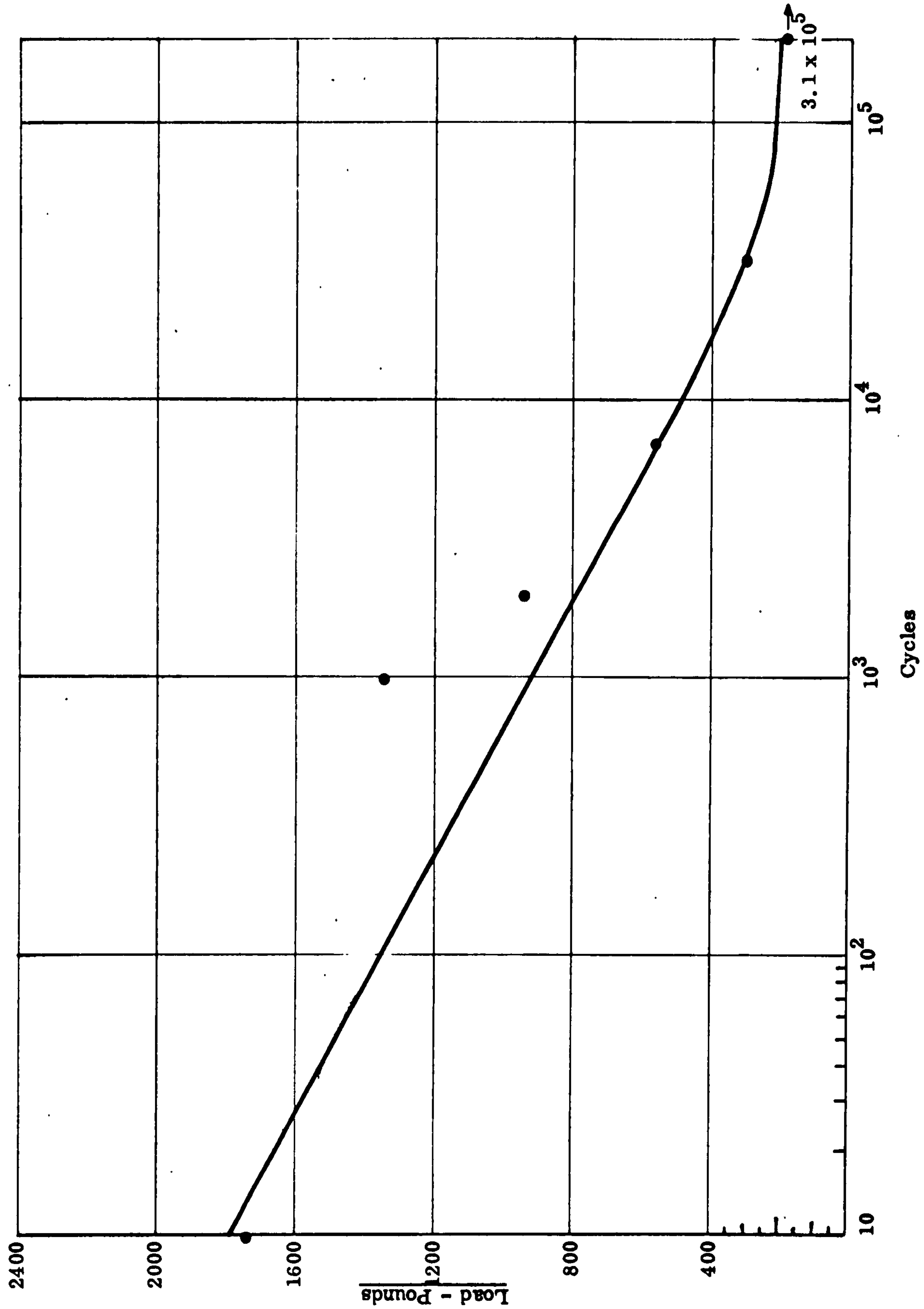
Load vs Temperature Properties - .078 Spot Welded Sheet



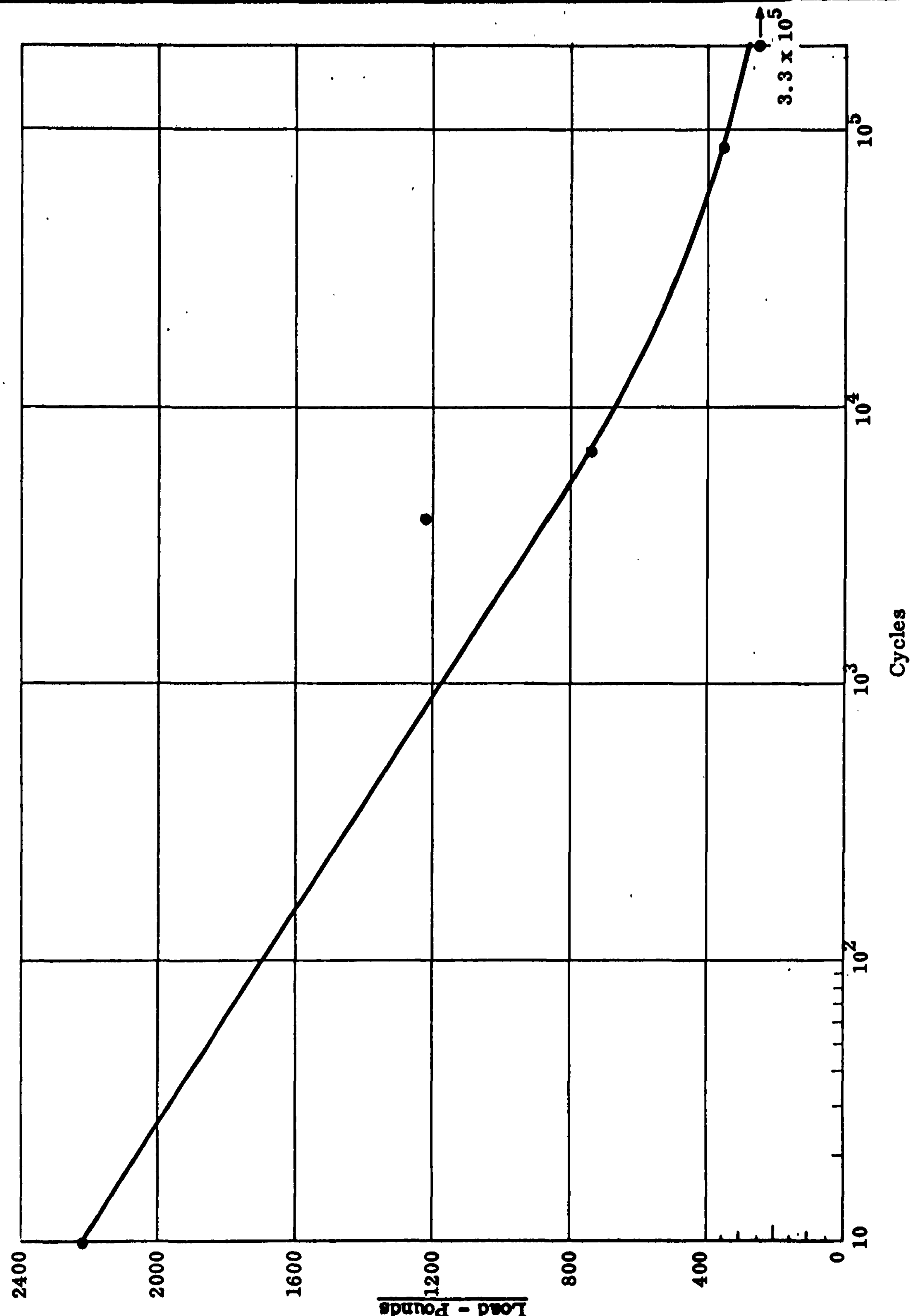
Pull-out Fatigue Tests - Half Hard Stainless Steel Spot Welded Sheet - Room Temperature Tests



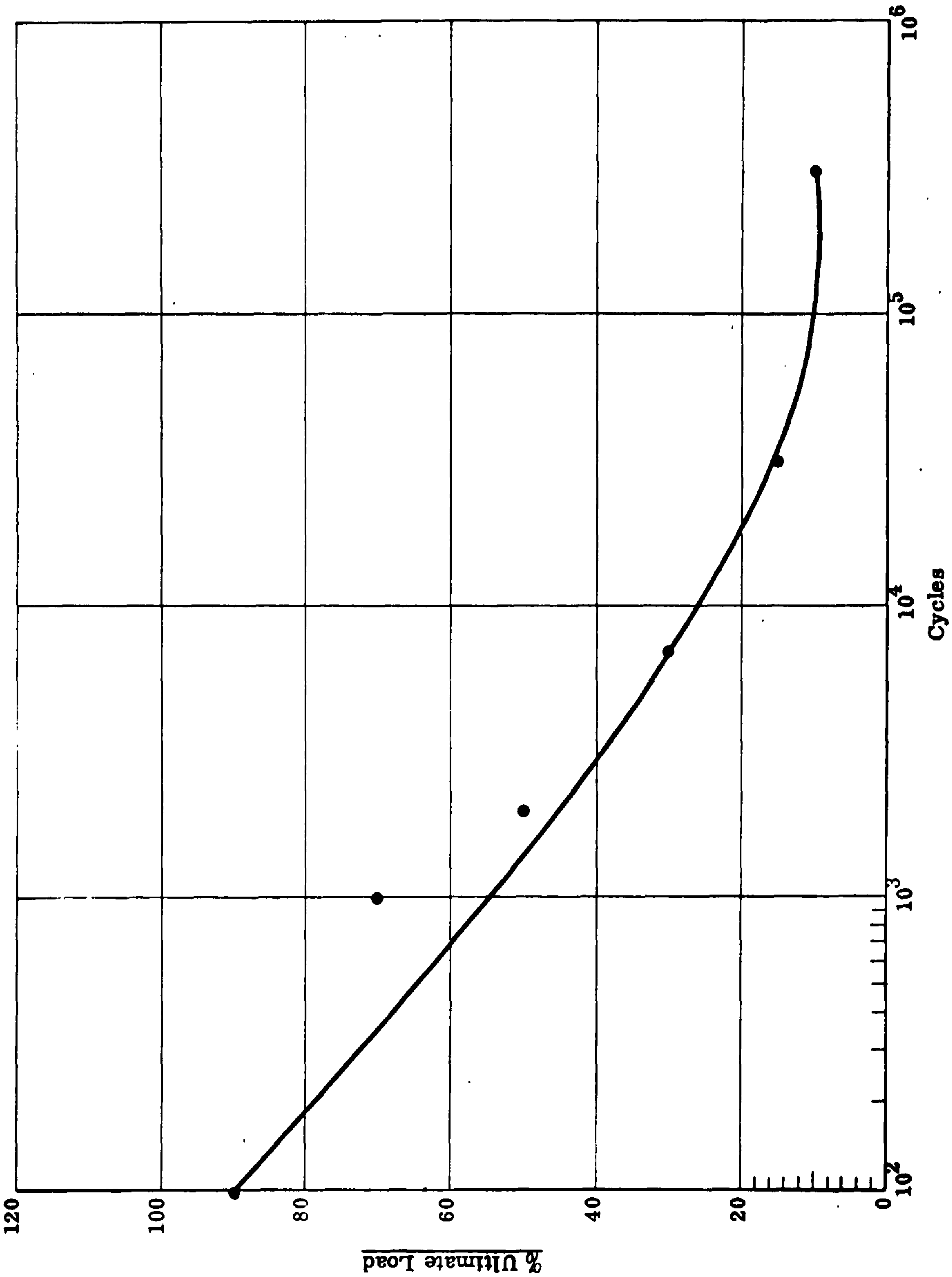
Pull-Out Fatigue Tests - Halfhard 302 Spot Welded Sheet - Room Temperature



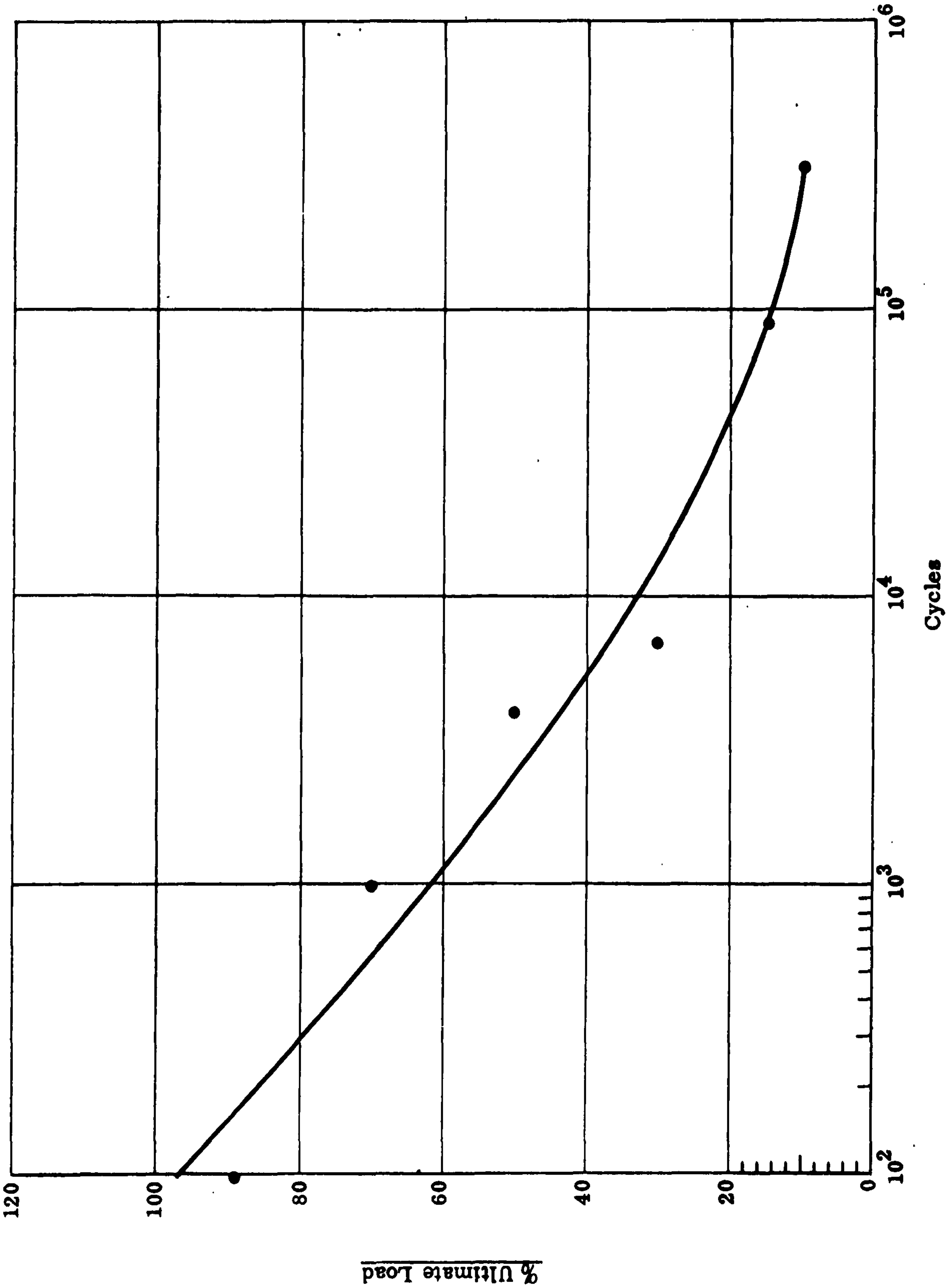
Tensile Shear Fatigue Test - .032 Inch Spot Welded Sheet - Room Temperature



Tensile Shear Fatigue Tests - .040 Inch Spot Welded Sheet - Room Temperature



Tensile Shear Fatigue Tests - .032 Inch Spot Welded Sheet - Room Temperature



Tensile Shear Fatigue Tests - .040 Inch Spot Welded Sheet - Room Temperature

MECHANICAL PROPERTIES OF RENE' 41

MATERIAL IDENTIFICATION (COML.)	MATERIAL STATUS
Rene' 41	Production
HEAT OR BATCH NUMBER	**FORM**
R-110, R-121	Sheet

PROCESSING CONDITION

See Data Below

OBJECT OF TEST	RAC DATA REF.
To Evaluate Tungsten Inert Gas Fusion Welds in Rene' 41	M.R. Report No. 58-90-1

SPECIMEN TYPE Standard Sheet Metal Tensile and Bend Test Specimens Per Federal Test Method Standard No. 151a, dated May 6, 1959. Elevated Temperature Tensile Tests Per ARTC-13T-1, July, 1957.

TEST METHOD: Standard Sheet Metal Tensile Tests and Bend Test Specimens Tested in Accordance With Federal Test Method Standard No. 151a, dated May 6, 1959. Elevated Temperature Tensile Tests in Accordance With ARTC-13T-1, July, 1957.

CHEMICAL ANALYSIS OF SOLUTION ANNEALED BASE METAL
AS SUPPLIED BY PRODUCER

	.032 Gage	.032 Gage	.062 Dia. Welding Wire
C	.12	.09	.10
Mn	.07	.07	.07
Si	.06	.07	.05
Cr	19.05	19.00	19.01
Co	11.03	11.00	11.12
Mo	9.79	9.80	9.82
Ti	3.17	3.23	3.24
Al	1.52	1.58	1.49
Fe	.48	.30	.30
B	.0030	.0030	.0037
S	.008	.008	-
Ni	Bal.	Bal.	Bal.
Heat No.	R-110	R-121	R-074

PHYSICAL PROPERTIES OF SOLUTION ANNEALED BASE METAL AS SUPPLIED BY THE PRODUCER

	.032 Gage	.090 Gage
.2% Yield psi	75,700	76,130
Ultimate psi	144,300	147,800
.02% Yield psi	69,400	67,700
% Elong. in 2"	30	35
Hardness	RC 27	RC 26
Heat No.	R-110	R-121

PHYSICAL PROPERTIES OF BASE METAL IN THE AGED CONDITION AT ROOM AND ELEVATED TEMPERATURES

	Aged/1400°F/16 Hrs.			Elev. Temp. Tests*		
Gage	YS ksi	UTS ksi	% E. in 2"	YS ksi	UTS ksi	% E. in 2"
.032	161.3	192.3	8.0	129.2	150.0	9.0
.032	159.0	193.2	8.5	127.4	151.6	10.5
.032	163.7	200.0	9.0	135.4	166.5	10.0
.090	142.9	188.0	13.0	123.4	160.8	9.0
.090	145.8	193.4	15.5	131.8	154.2	9.5

* Elevated Temperature Tests Were Conducted At 1400°F ± 5°F After Holding Specimens For 20 Minutes At Temperature.

WELD AND STRETCH TENSILE TEST RESULTS
.032 GAGE (ROOM TEMPERATURE)

Grain Transverse to Length of Specimens

Specimen No.	% Stretch	Yield Strength psi	Ultimate Tensile Strength psi	% E. in 2"	Location of Fracture
A-4	0	133,600	167,900	3.5	In Weld
A-13	0	142,300	173,400	4.0	In Weld
A-5	5	130,100	165,100	6.0	In Weld
A-3	10	123,800	171,400	5.5	In Weld
A-8	10	141,500	172,300	4.0	In Weld
A-15	11	137,800	169,200	4.5	Base Metal
A-12	12	128,800	162,500	3.5	In Weld
A-10	20	141,700	171,700	4.0	In Weld

Grain Parallel to Length of Specimens

Specimen No.	% Stretch	Yield Strength psi	Ultimate Tensile Strength psi	% E. in 2"	Location of Fracture
A-11	0	146,500	176,700	4.0	In Weld
A-16	0	132,700	157,100	1.5	In Weld
A-6	4	129,800	157,400	3.0	In Weld
A-14	5	145,600	176,600	6.0	In Weld
A-9	5	140,000	173,300	5.0	In Weld
A-1	10	139,300	167,900	4.5	In Weld
A-2	10	134,900	171,600	5.5	In Weld
A-7	15	142,900	169,700	4.0	In Weld
B-1	-	99,400	132,900	1.0	Edge of Weld
B-2	-	105,600	123,600	1.0	Edge of Weld
B-3	-	143,800	163,100	2.0	Edge of Weld
B-4	-	127,200	139,900	2.0	Edge of Weld
B-5	-	132,900	153,400	1.0	Edge of Weld
B-6	-	140,000	161,900	1.5	Edge of Weld
B-7	-	125,500	137,300	1.0	Edge of Weld
B-8	-	140,000	163,100	1.5	Edge of Weld
C-1	-	141,500	171,400	3.0	Base Metal
C-2	-	134,100	172,600	3.5	Edge of Weld
C-3	-	139,400	172,700	5.0	In Weld
C-4	-	138,200	173,300	4.0	Edge of Weld
C-5	-	155,000	174,400	4.0	In Weld
C-6	-	161,800	174,500	5.5	In Weld
C-7	-	141,200	158,800	3.0	In Weld
C-8	-	129,200	169,600	3.5	In Weld

(continued on next page)

NOTES: 1. All specimens were welded in the solution annealed condition.

2. Specimens #A-1 through A-16 were stretched prior to welding to simulate a formed part. Weld reinforcement was removed.

3. All specimens were .032 gage Rene' 41 sheet, 1-1/4" wide x 8" long prior to stretching.

4. After stretching in tensile machine, all specimens were sheared at center of 8" length and joined by butt welding.

5. Percent stretch was measured between both 1" and 2" gage marks to establish average.

6. Specimens #B-1 through C-4 did not have the weld reinforcement removed in order to check notch sensitivity.

7. Weld reinforcement was removed from specimens #C-5 through C-8. All specimens were re-solution annealed at 1975°F ± 25°F, air quenched and aged at 1400°F for 16 hours before testing.

WELD TENSILE TEST RESULTS, .090 GAGE (ROOM TEMPERATURE)

Specimen No.	Yield Strength psi	Ultimate Tensile Strength psi	% Elong. in 2"	% Elong. in 1/2"	Location of Fracture
2-1	136,800	158,800	3.5	10.0	In Weld
2-2	139,100	149,500	2.0	8.0	In Weld
3	129,900	156,900	3.5	8.0	Edge of Weld
4-1	134,800	160,200	3.5	10.0	In Weld
4-2	138,800	164,000	4.5	10.0	In Weld
4-3	138,800	163,500	4.5	10.0	In Weld
20-1	132,200	161,700	5.5	10.0	Edge of Weld
20-2	138,900	163,500	4.0	12.0	In Weld
21	135,000	161,700	5.0	10.0	In Weld
22	135,100	164,100	5.0	10.0	In Weld
24-1	137,900	161,300	5.0	10.0	In Weld
24-2	135,500	154,700	3.5	10.0	In Weld
2W	139,200	168,700	7.0	8.0	In Weld
3W1	139,200	168,100	5.0	10.0	In Weld
3W-2	137,600	164,700	5.0	10.0	In Weld
4W-1	133,400	163,600	6.5	10.0	In Weld
4W-2	137,200	163,100	5.0	8.0	In Weld
13W	131,400	153,600	3.0	10.0	In Weld
14W-1	135,500	154,500	3.0	10.0	In Weld
14W-2	136,200	158,300	4.0	12.0	In Weld
21W	139,800	164,900	5.0	8.0	In Weld
22W	137,500	167,200	6.5	14.0	In Weld
24W	132,800	161,500	5.0	12.0	In Weld
26W	133,300	157,700	4.0	6.0	In Weld

NOTES:

1. All specimens were welded in the solution annealed condition.
2. Specimens identified by the letter "W" were re-solution annealed at 1975°F ± 25° after welding and water quenched.
3. Specimens without the identifying letter "W" were re-solution annealed at 1975°F ± 25°F after welding and air quenched.
4. All specimens were aged at 1400°F for 16 hours before testing.
5. Weld bead was removed from all specimens.

WELD TENSILE TEST RESULTS (ROOM TEMPERATURE)

Condition 1. Material was welded in the 1975°F ± 25°F solution annealed condition. Weld bead was removed and specimens were tested with no subsequent heat treatment.

Condition 2. Material was welded in fully heat treated and aged condition. (Solution annealed at 1975°F + 25°F, water quenched, and aged at 1400°F for 16 hours.) Weld bead was removed and specimens were tested with no subsequent heat treating.

Condition 3. Material was welded in the 1975°F ± 25°F solution annealed condition. Specimens were then aged at 1400°F for 16 hours, weld bead was removed, and specimens were tested.

Condition 1

Specimen No.	Yield Strength psi*	Ultimate Tensile Strength psi	% Elong. in 2"	% Elong. in 1/2"	Location of Fracture
1	85,300	139,100	16.5	22.0	In weld
2	84,800	142,000	20.5	22.0	Edge of weld
3-1	90,700	110,700	5.0	10.0	Defect in weld
3-2	87,800	140,800	17.5	26.0	In weld
4	87,000	124,000	8.5	8.0	In weld
5-1	85,700	141,300	21.0	26.0	In weld
5-2	77,900	146,000	32.0	46.0	Base metal
6-1	87,800	150,800	23.5	26.0	In weld
6-2	88,400	151,100	21.0	24.0	In weld
8	86,000	135,900	14.5	20.0	In weld
24	83,300	148,700	26.0	26.0	In weld

Condition 2

Specimen No.	Yield Strength psi*	Ultimate Tensile Strength psi	% Elong. in 2"	% Elong. in 1/2"	Location of Fracture
12-1	See notes	38,300	1.0	4.0	See notes
12-2	See notes	71,400	1.0	4.0	See notes
12-3	102,500	118,300	2.5	10.0	See notes
12-4	See notes	53,300	0.5	2.0	See notes
12-5	See notes	60,100	0.5	2.0	See notes
12-6	See notes	62,100	0.5	2.0	See notes
12-7	108,500	146,600	5.0	16.0	In weld
15-1	110,400	153,600	6.0	24.0	In weld
15-2	104,000	140,200	4.0	14.0	In weld
15-3	105,800	148,400	6.0	20.0	In weld
15-4	103,800	144,200	4.5	18.0	In weld
15-5	104,700	130,600	3.0	14.0	In weld
15-6	102,700	148,800	6.0	22.0	In weld

WELD TENSILE TEST RESULTS (ROOM TEMPERATURE) - cont'd

Condition 3

Specimen No.	Yield Strength psi*	Ultimate Tensile Strength psi	% Elong. in 2"	% Elong. in 1/2"	Location of Fracture
1A-1	131,500	169,900	5.0	14.0	In weld
1A-2	149,800	185,200	7.0	14.0	In weld
2A	146,300	159,500	3.0	8.0	In weld
3A	139,500	160,500	3.5	8.0	In weld
4A	136,400	159,100	3.5	10.0	In weld
6A	140,100	170,800	6.0	12.0	In weld
14A	125,700	176,500	8.5	16.0	In weld
20A	137,000	169,800	6.5	14.0	In weld
21A	144,500	176,600	6.5	10.0	In weld
22A	141,200	170,600	6.0	10.0	In weld
24A	132,200	161,500	4.0	8.0	In weld

* Extensometer yield, 0.2% offset, 2 inch gage.

NOTES: 1. Specimens No. 12-1, 12-2, 12-4, 12-5 and 12-6 had gross defects in the welds. Specimen No. 12-3 had a slight defect in the weld. Specimen 12-7 had no defect in the weld. All specimens identified with prefix 12 were cut from the same butt welded plate. Because of gross defects in welds, no yield limit could be ascertained.

2. Elongation in 1/2" was measured in area of fracture of test piece.

GUIDED BEND TEST RESULTS

Specimen No.	Type Specimen	Angle of Bend	Remarks
1	Welded	30°	Failed in weld - failure started at edge of test piece
2	Welded	50°	Failed in weld
3	Welded	27°	Failed in weld
4	Welded	85°	Failed in weld
5	Welded	60°	Failed in weld
1C	Base metal	135°	No evidence of cracks
2C	Base metal	140°	No evidence of cracks
3C	Base metal	145°	No evidence of cracks
4C	Base metal	145°	No evidence of cracks
5C	Base metal	135°	No evidence of cracks
6C	Base metal	140°	No evidence of cracks

NOTES: 1. All specimens were bent over a 5 T radius. Actual ram dimension was .980 and the thickness of the specimens was .100".

2. The control specimens (base metal) were bent beyond the 105° angle to see if cracking could be initiated, but no evidence of cracking was found at angles up to 145°.

3. All specimens were in the 1975°F + 25°F solution annealed condition, re-solution annealed after welding at 1975°F ± 25°F, water quenched, and aged at 1400°F for 16 hours.

MECHANICAL PROPERTIES OF RENE' 41

MATERIAL IDENTIFICATION (COML.)	MATERIAL STATUS
Rene' 41	Production
HEAT OR BATCH NUMBER	**FORM**
R-110	.032 Sheet

PROCESSING CONDITION

See Data Below

OBJECT OF TEST	RAC DATA REF.
To Evaluate Resistance Spot Welding of Rene' 41	ESR 61-230 M.R. Report No. 58-102-1

SPECIMEN TYPE Single Spot Shear Specimens Per MIL-W-6858A, dated 9 July 1957. Tension Pullout Specimens Per MIL -W-4994, dated 28 October 1955 or Equivalent.

TEST METHOD: Single Spot Shear Specimens and Tension Pullout Specimens Were Tested in Accordance With MIL-W-6858A, dated 9 July 1957, and MIL-W-4994, dated 28 October 1955, respectively.

CHEMICAL ANALYSIS AS SUPPLIED BY PRODUCER

C	Mn	Si	Cr	Co	Mo	Ti	Al	Fe	B	S	Ni
.12	.07	.06	19.05	11.05	9.79	3.17	1.52	.48	.005	.008	Bal.

TENSILE SHEAR AND TENSION PULL OUT VALUES (LBS) WELDED IN SOLUTION HEAT TREATED CONDITION*

Tensile Shear Strength			Strength In Tension
1780	1760		938
1820	1790		880
1750	1780		904
1780	1840		804
1740	1810		1120
1800	1810		822
1760	1830		766
1810	1810		968
1750	1790		812
1760	1810		968
	1789	Average	898

(continued on next page)

MIL-W-6858A Requirements:

Shear Min. Avg. lb/weld - 1280

Tension Min. Avg. lb/weld - 320 (25% x 1280)

Shear Test Variation - $\frac{\text{Range}}{\text{Average}} = \frac{1840 - 1740}{1789} =$ .06 (Required .25 max.)

Actual Ductility - $\frac{\text{Actual Avg. Tension Strength}}{\text{Actual Avg. Shear Strength}} = \frac{898}{1789} \times 100 = 50.2\%$

Specification Ductility - $\frac{\text{Actual Avg. Tension Strength}}{\text{Min. Spec. Avg. Shear}} = \frac{898}{1280} \times 100 = 70\%$

* Solution Heat Treated Condition: 1950°F - water quenched.

TENSILE SHEAR AND TENSION PULL OUT VALUES (LBS)
WELDED IN THE AGED CONDITION*

Tensile Shear Strength		Strength In Tension
1868	1942	820
1838	1934	920
1837	1942	864
1838	1940	912
1958	1938	984
1938	1942	750
1940	1938	928
1940	1922	890
1942	1938	724
1946	1936	912
	1921	878

MIL-W-6858A Requirements:

Shear Min. Avg. lb/weld - 1280

Tension Min. Avg. lb/weld - 320 (25% x 1280)

Shear Test Variation - $\frac{\text{Range}}{\text{Average}} = \frac{1958 - 1837}{1921} =$ .063 (Required .25 max.)

Actual Ductility - $\frac{\text{Actual Avg. Tension Strength}}{\text{Actual Avg. Shear Strength}} = \frac{878}{1921} \times 100 = 45.7\%$

Specification Ductility - $\frac{\text{Actual Avg. Tension Strength}}{\text{Min. Spec. Avg. Shear}} = \frac{878}{1280} \times 100 = 76\%$

* Aged Condition: 1400°F - 16 Hours

TENSILE SHEAR AND TENSION PULL OUT VALUES (LBS)
WELDED IN THE SOLUTION HEAT TREATED CONDITION AND AGED* AFTER WELDING

Tensile Shear Strength		Strength In Tension
1530		460
1600		480
1220		490
1420		400
1580		580
1600		460
1680		420
1380		480
1800		420
1400		440
1521	Average	463

MIL-W-6858A Requirements:

Shear Min. Avg. lb/weld - 1280

Tension Min. Avg. lb/weld - 320 (25% x 1280)

Shear Test Variation - $\frac{\text{Range}}{\text{Average}} = \frac{1800 - 1220}{1521} =$ .38 (Required .25 max.)

Actual Ductility - $\frac{\text{Actual Avg. Tension Strength}}{\text{Actual Avg. Shear Strength}} = \frac{463}{1521} \times 100 = 30.4\%$

Specification Ductility - $\frac{\text{Actual Avg. Tension Strength}}{\text{Min. Spec. Avg. Shear}} = \frac{463}{1280} \times 100 = 36\%$

* Aged Condition: 1400°F - 16 Hours

TENSILE SHEAR AND TENSION PULLOUT VALUES (LBS)
WELDED IN THE SOLUTION HEAT TREATED CONDITION,
RESOLUTION HEAT TREATED AND AGED* AFTER WELDING

Tensile Shear Strength			Strength In Tension
1740	1700		356
1780	1640		394
1744	1616		406
1688	1596		402
1812	1782		390
1728	1770		424
1772	1576		
	1710	Average	395

MIL-W-6858A Requirements:

Shear Min. lb/weld - 1280

Tension Min. lb/weld - 320 (25% x 1280)

Shear Test Variation - $\frac{\text{Range}}{\text{Average}} = \frac{1812 - 1576}{1710} =$ .13 (Required .25 Max.)

Actual Ductility - $\frac{\text{Actual Avg. Tension Strength}}{\text{Actual Avg. Shear Strength}} = \frac{395}{1710} \times 100 = 23.1\%$

Specification Ductility - $\frac{\text{Actual Avg. Tension Strength}}{\text{Min. Spec. Avg. Shear}} = \frac{395}{1280} \times 100 = 30\%$

* Resolution Heat Treat (1950°F - Water Quench), Aged (1400°F - 16 Hours)

TENSILE SHEAR STRENGTH (LBS) AT ELEVATED TEMPERATURE*

Tensile Shear Strength	Test Temperature °F
1760	1000
1855	1000
2080	1000
1835	1200
1650	1200
1620	1200
1125	1400
1335	1400
1245	1400
725	1600
720	1600
850	1600
570	1800
575	1800
595	1800
265	2000
290	2000
280	2000

* Exposure Time: 30 Minutes

MECHANICAL PROPERTIES OF RENE' 41

MATERIAL IDENTIFICATION (COML.)	MATERIAL STATUS
Rene' 41	Production
HEAT OR BATCH NUMBER	**FORM**
Unavailable	Sheet

PROCESSING CONDITION

Solid Treated 1975 °F W.Q., and Aged 1400°F/16 hours.

OBJECT OF TEST	RAC DATA REF.
Determine mechanical properties at elevated temperature.	RAC unpublished data

SPECIMEN TYPE

Tension & stress rupture - STD .500 wide sheet spec. as per ARTC-13-T June 1959. Compression - 3 x .8 sheet specimen.

TEST METHOD:

Tension compression & stress rupture tests as per ARTC-13 June 1959.

RENE' 41

TENSILE PROPERTIES VERSUS TEMPERATURE (1/2 HOUR SOAK)

0.050 SHEET - TRANSVERSE SHEET

Test Temp. (°F)	Ultimate (ksd)	.2% Yield (ksi)	Elong. (% in 2")	Remarks
75	204	158	15.5	
75	203	145	23.0	NIMT
75	204	146	25.0	
900	179	138	21.0	
900	180	138	16.5	NIMT
900	180	137	25.0	
1200	172	131	6.5	BAGM
1200	168	130	7.0	BAGM
1200	167	134	8.5	BAGM
1400	130	117	2.0	BOGL
1400	140	120	3.5	BOGL
1400	142	118	3.0	
1500	119	109	4.0	
1500	117	113	3.5	BOGL
1500	115	106	3.0	BOGL
1600	90	83	4.0	BOGL
1600	89	83	5.0	BOGL
1600	85	*	4.5	BOGL
1700	47.5	43.0	3.5	BOGL
1700	50.5	47.5	4.0	BOGL
1700	54.0	53.0	3.5	BOGL
1800	28.2	27.8	3.0	BOGL
1800	24.8	24.5	3.5	BOGL
1800	25.7	24.4	5.5	BOGL

* Recorder malfunctioned
NIMT Failure not in the middle third of gage length
BAGM Broke at the gage mark (1200°F specimens had gage marks scribed on)
BOGL Broke outside of gage length (on upper side of specimen)

RENE' 41

EFFECTS OF STRAIN ON TENSILE PROPERTIES VERSUS TEMPERATURE (1/2 HR. SOAK)

.050 SHEET - TRANSVERSE TESTS

Test Temp. (°F)	Prior Strain (%)	Ultimate (ksi)	.2% Yield (ksi)	Elongation % in 2"	Remarks
75	10	215	185	16.5	
75	10	219	191	15.5	
75	20	223	199	12.5	
75	20	228	200	10.5	
1200	10	194	163	11.5	
1200	10	196	167	-	Grip Failed
1200	20	211	184	4.0	BAGM
1200	20	211	181	6.5	BAGM
1500	10	124	*	-	Grip Failed
1500	10	101	87.0	3.0	BOGL
1500	20	102	90.5	3.0	BOGL
1500	20	101	92.5	3.5	BOGL
1800	10	24.6	18.6	5.0	BOGL
1800	10	28.8	21.3	5.5	BOGL
1800	20	22.6	18.9	6.0	BOGL
1800	20	22.4	18.0	-	Grip Failed

* Recorder malfunctioned

NOTE: Grip end of all specimens were inadvertently undercut during manufacture. Three of these failed at grip.

RENE' 41

COMPRESSION PROPERTIES AT ROOM TEMPERATURE

STRAINED AND UN-STRAINED SPECIMENS

.050 SHEET

Grain * Direction	Pre-Age ** - Strain (%)	.2% Yield (ksi)	Modulus psi 10^6
Trans.	None	169	32.6
		163	31.2
		168	
Long.		163	32.6
		159	32.7
		165	30.6
Trans.	10	214	--
	10	198	32.8
	20	232	32.6
	20	224	31.5

* Trans. - Grain transverse to test direction
Long. - Grain in same direction of test

** Strained in tension in the same direction as tested..

RENE' 41 SHEET

STRESS - TO - RUPTURE

Nominal Gage (inches)	Test Temp. (° F)	Stress (ksi)	Time to Rupture (hours)	Elongation at Failure (% in 2")
.020	1400	60	1.7	Grip Failure
.020	1400	60	5.2	Grip Failure
	1400	50	31.7	2.0
	1400	35	245.1	4.5
	1500	35	6.2	2.2
	1500	30	39.7	6.0
	1500	25	57.4	8.0
	1500	24	78.7	5.0
	1500	18	383.6	11.5
	1600	25	5.5	5.0
	1600	20	23.0	9.5
	1600	15	66.1	11.5
	1600	12	204.2	11.0
	1700	10	27.2	22.5
.020	1700	5		
.070	1700	18	12.6	22.0
.070	1700	13	54.3	24.0
.070	1700	9	189	26.0

MECHANICAL PROPERTIES OF "K" MONEL

MATERIAL IDENTIFICATION (COML.)
"K" Monel

MATERIAL STATUS
Production

HEAT OR BATCH NUMBER
Unavailable

FORM
Sheet

PROCESSING CONDITION
See below

OBJECT OF TEST
Determine effects of variations in heat treatment.

RAC DATA REF.
ESRMR 185 dated September 15, 1960

SPECIMEN TYPE
As per Fed. Test Std. No. 151a Method 211.1; May 1959

TEST METHOD:

As per Fed. Test Method Std. No. 151a Method 211.1 dated 6 May 1959.

The investigation was accomplished to determine to what extent the properties of "K" Monel sheet would be affected by deviation from 16 hours at 1090°F heat treatment cycle. Specimens tested were aged for 8 and 16 hours at 1040°F, 1090°F, and 1140°F. Cooling rates were also varied, where indicated, as per accompanying tables and figures. The effect of this altered cooling rate was adjusted to make it compatible with an 8 hour day and to require minimum furnace attention.

"K" Monel

Tensile Strength Versus Pre-Aging Strain

Longitudinal Tests - .040 Sheet-1090°F Age

Age Time Hrs.	Prestrain (%)	Ultimate (ksi)	.2% Yield (ksi)	Elong. (% in 2")
16	None	151	106	24.0
16	None	149	104	24.0
16	5	151	108	23.5
16	5	155	111	23.0
16	10	158	116	20.0
16	10	159	117	20.0
16	15	165	127	17.0
16	15	164	126	17.5
8	None	159	105	23.0
8	None	154	104	24.0
8	5	157	112	23.0
8	5	155	111	22.5
8	10	159	120	20.0
8	10	160	122	19.5
8	15	163	132	17.0
8	15	165	134	18.0

NOTE: Cooling rate from aging temp. as per Page 7
QQ-N-286 requirements are: 130 ksi, tsu and
90 ksi, tys with 15% elongation.

"K" Monel

Tensile Strength Versus Aging Temperature

Longitudinal Tests - .040 Sheet

Aging Temp. (°F)	Aging Time (Hrs.)	Ultimate (ksi)	.2% Yield (ksi)	Elong. (% in 2")
1040	8	138	90.5	32.0
1040	8	136	89.0	332.0
1040	16	143	97.5	30.0
1040	16	145	99.0	28.0
1090	8	151	104	27.0
1090	8	153	108	24.5
1090	16	153	109	25.5
1090	16	155	112	23.5
1140	8	151	106	20.5
1140	8	153	111	22.0
1140	16	151	107	22.0
1140	16	149	104	22.0

NOTE: Cooling rate from aging temp. as per Page 7
QQ-N-286 requirements are 130 ksi, uts and
90 ksi tys with 15% elongation.

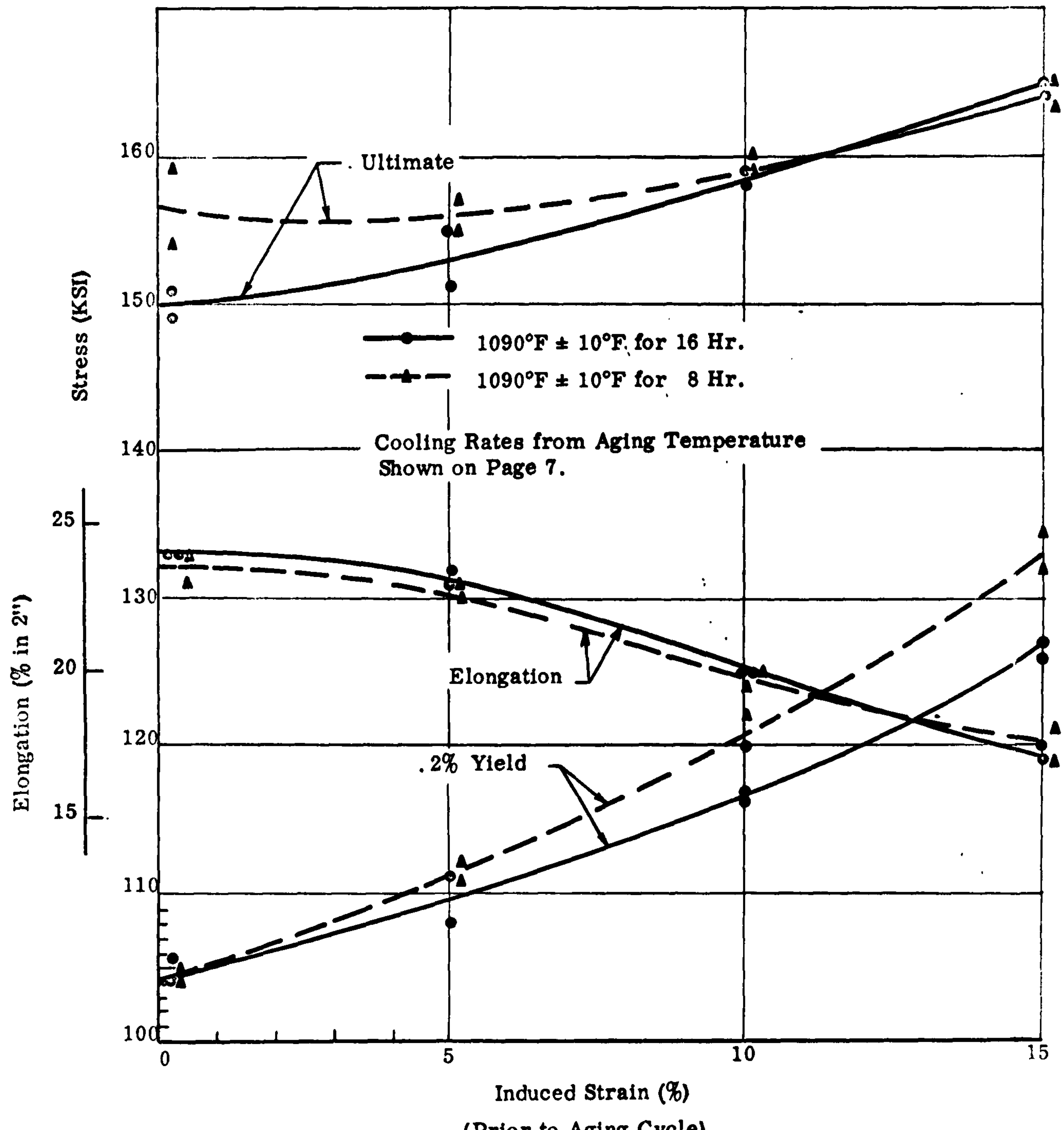
"K" Monel (.040 Sheet)

Strengths of Formed and Aged Parts

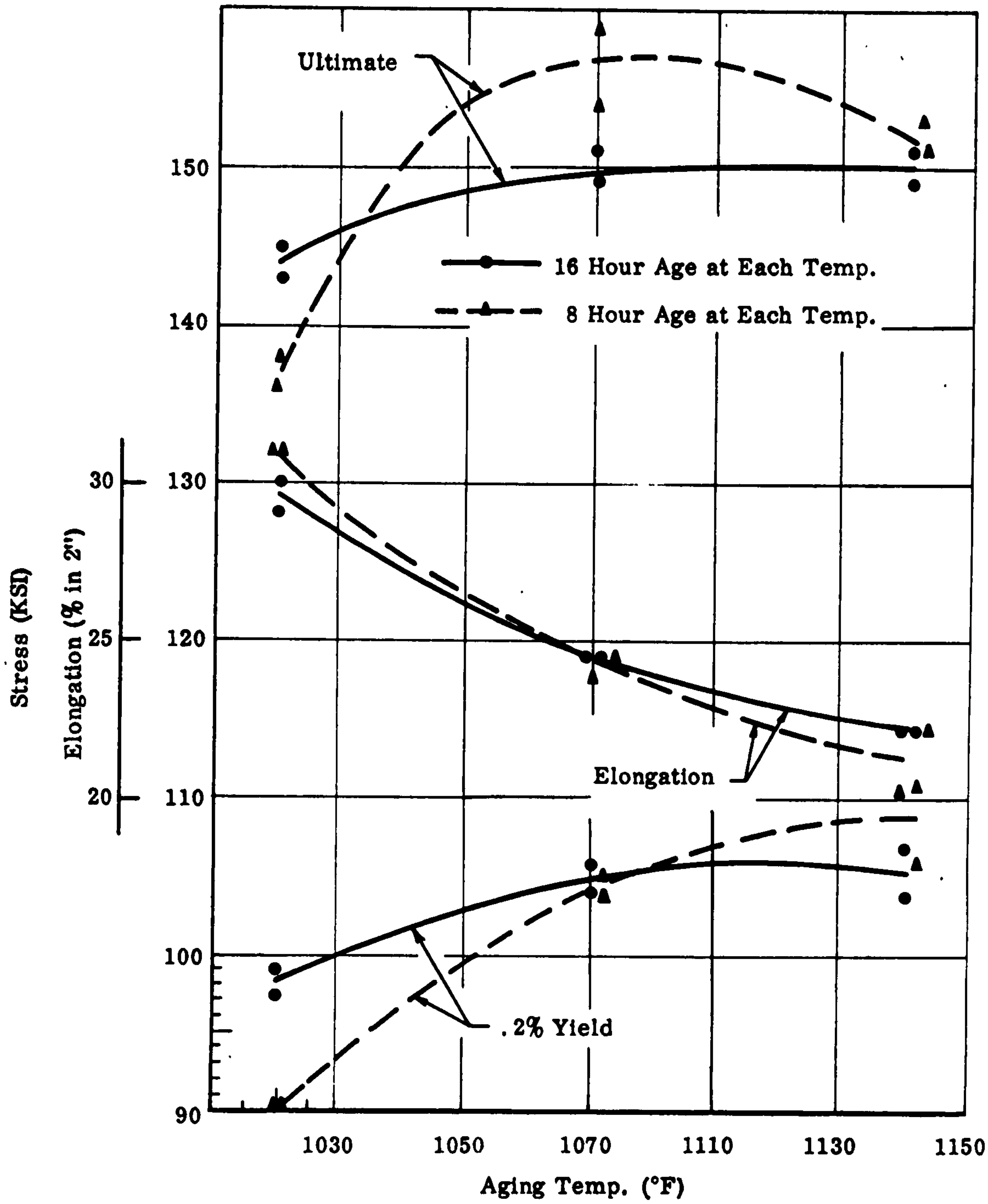
Ultimate (ksi)	.2% Yield (ksi)	Elong. (% in 2")
155	122	18.0
157	110	20.5
155	107	20.0
157	113	18.0
162	112	20.0
156	119	18.5
154	109	20.0
155	112	18.5
154	111	19.0
157	113	19.0

NOTE: These specimens were cut from a canopy part made in the production shop on production tooling and heat treated with production equipment.

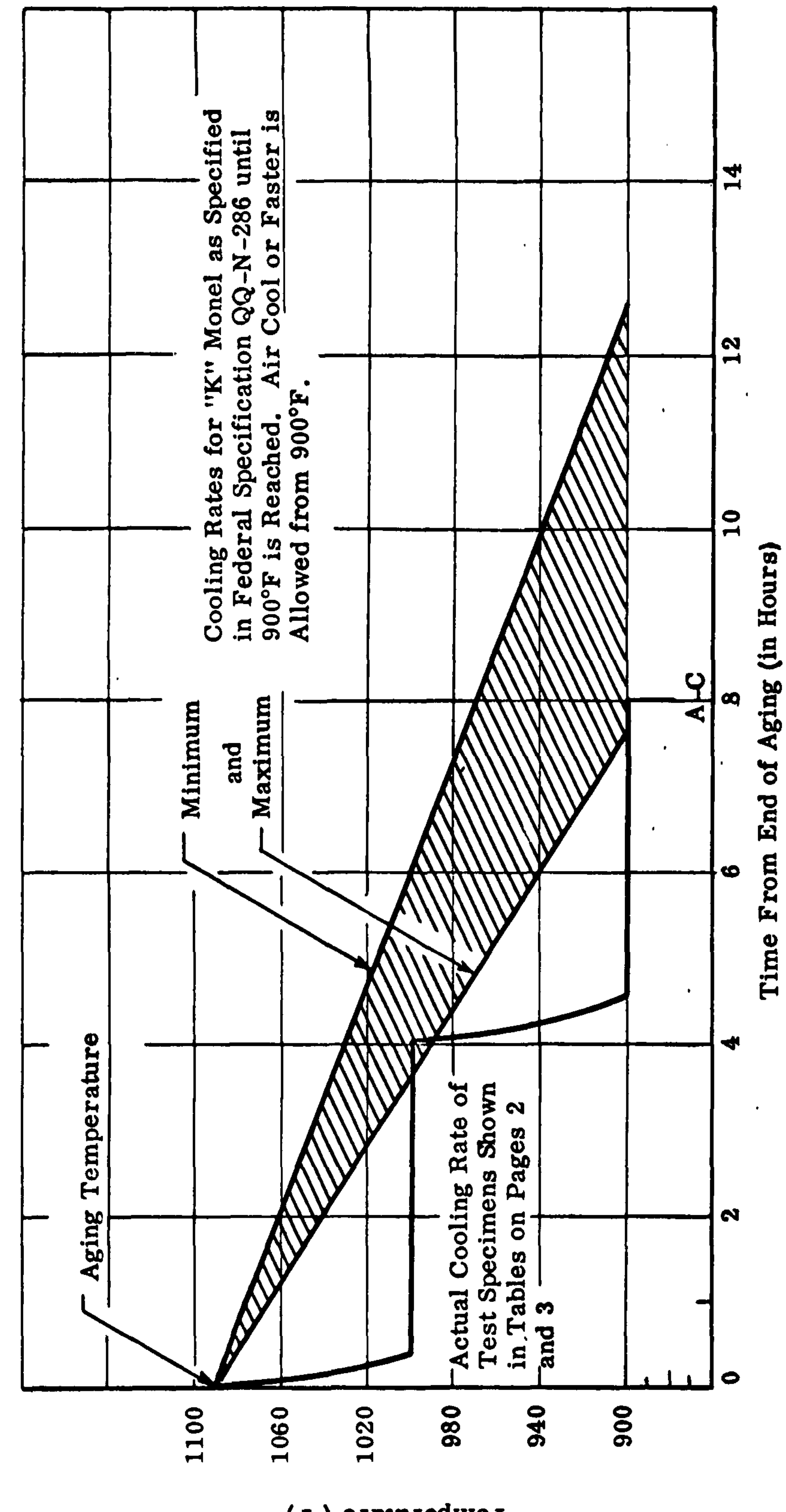
The gage section of these specimens was so arranged as to fall on what appeared to be the more severely worked areas of the part.



Room Temperature Strength vs. Strain - Transverse Specimens



"K" Monel - Mechanical Properties vs. Aging Temperature



Cooling Rate for Aging "K" Monel

CODE: 1.A.7.9.1

PROPERTIES OF ELECTROFORMED NICKEL

MATERIAL IDENTIFICATION (COML.) Electroformed Nickel	MATERIAL STATUS Experimental
HEAT OR BATCH NUMBER Unavailable	FORM Sheet
PROCESSING CONDITION As Deposited	
OBJECT OF TEST To determine tensile properties of electroformed nickel.	RAC DATA REF. ERMR 4745 dated February 3, 1959 plus addendum I, April 2, 1959 and Addendum II April 9, 1959.
SPECIMEN TYPE See below	

TEST METHOD:

Four samples of electroformed nickel sheet were submitted for evaluation. These sheets, which were obtained from Electroforms, Inc. of Connecticut, were of the following dimensions:

Designation	Length Inches	Width Inches	Nominal Thickness Inches
A	14	1-1/2	0.025-0.028
B	13	1-3/4	0.028-0.030
C	9-1/2	8-1/2	0.008-0.010
D	10-1/4	9-1/4	0.010-0.015

Subsize tensile specimens 3 in. long with a gage section 0.250 in. by 1 in. were machined from the material. Specimens from both longitudinal and transverse directions were cut from sheets C and D. Testing was performed at room temperature on the Baldwin 60,000 lb. machine. Ultimate load and elongation to failure data were recorded, and are indicated on an accompanying table.

Three standard flat tensile specimens were machined from sheet D, and tested in the 60,000 lb. Baldwin machine. Modulus determinations were made from the recorded load-strain curves. Data are presented below:

Spec. No.	Thickness - in.	E- 10^6psi	UTS psi	% Elong. in 2"
M1	0.016	29.9	90,000	7.0
M2	0.013	29.0	99,800	7.5
M3	0.012	22.7	87,800	7.0

Also tested (under Addendum I) were specimens obtained from Allied Research and Engineering Company. The material was supplied as longitudinal strip sections, 0.05 inch thick, cut from a large electroformed cylinder. The effect of the curvature was deemed negligible and standard sheet tensile specimens were prepared.

Because of some difficulty in exactly determining the elastic modulus of the material, two additional specimens were prepared using SR4 paper strain gages to obtain the elastic data.

The results of the series of tests are also presented in an accompanying table, with specimens numbered 1 to 6.

Under addendum II, four additional specimens again from Allied Research Engineering were tested. This material was supplied as flat sheet 0.025" thick. The data obtained therefrom are shown in the accompanying table as specimen numbers 7 to 10.

Room Temperature Tensile Data For Electroformed Nickel Sheet

Spec. No.	Thickness Inch		UTS (psi)	% Elong. in 1/2 inch
A1	0.0252		91,000	20
A2	0.0250		94,600	16
A3	0.0250		93,200	18
A4	0.0290		84,000	14
A5	0.0255		91,400	16
		AVERAGE	90,800	17
B1	0.0260		90,000	16
B2	0.0285		92,500	22
B3	0.0270		89,700	21
B4	0.0290		85,700	21
B5	0.0245		91,800	17
		AVERAGE	89,900	19
C1L*	0.0100		104,000	-
C2L	0.0110		105,000	7
C3L	0.0100		97,500	6
C4L	0.0125		87,500	8
C5L	0.0100		82,300	-
		AVERAGE	95,500	7
C1T**	0.0092		107,000	8
C2T	0.0091		106,000	8
C3T	0.0085		107,000	-
C4T	0.0095		106,000	12
C5T	0.0079		106,000	9
		AVERAGE	106,000	9
D1L	0.0130		98,500	-
D2L	0.0155		90,000	11
D3L	0.0165		97,500	10
D4L	0.0170		91,500	8
D5L	0.0170		102,000	10
		AVERAGE	95,900	10
D1T	0.0132		98,800	10
D2T	-		-	-
D3T	0.0200		81,100	16
D4T	-		-	-
D5T	0.0160		112,800	-
		AVERAGE	97,600	13

* Specimens cut in longitudinal direction

** Specimens cut in transverse direction

Mechanical Property Data for Electrolytic Nickel
(Allied Research and Eng'g. Company)

Specimen	Ult. Tens. Str. psi	Yield Stress 0.2% Offset psi	Percent Elongation in 2 Inches
1	103,000	90,600	13,0
2	110,000	95,000	10.0
3	111,000	100,000	11.0
4	103,000	95,000	14.0

Elastic Modulus Data

Specimen	$E \times 10^{-6}$ psi
5	28.3
6	30.0

Specimen	0.2% Yield Strength	Ult. Tensile Strength	% Elong. in 2 inches
7	124,000	131,000 psi	1.5
8	-*	118,000	6.0
9	-*	138,000	1.5
10	133,000	137,000	0

* Data not obtained.

MECHANICAL PROPERTIES OF STRETCHED PLEXIGLAS 55

MATERIAL IDENTIFICATION (COML.) Stretched Plexiglas 55 and Composite (see data below)	MATERIAL STATUS Production
HEAT OR BATCH NUMBER Unavailable	FORM Sheet
PROCESSING CONDITION Not Applicable	
OBJECT OF TEST Determine bearing strength and fatigue characteristics of several transparent materials	RAC DATA REF. ERMR 4772 dated Feb. 20, 1959
SPECIMEN TYPE See data below	

TEST METHOD:

Three materials were tested:

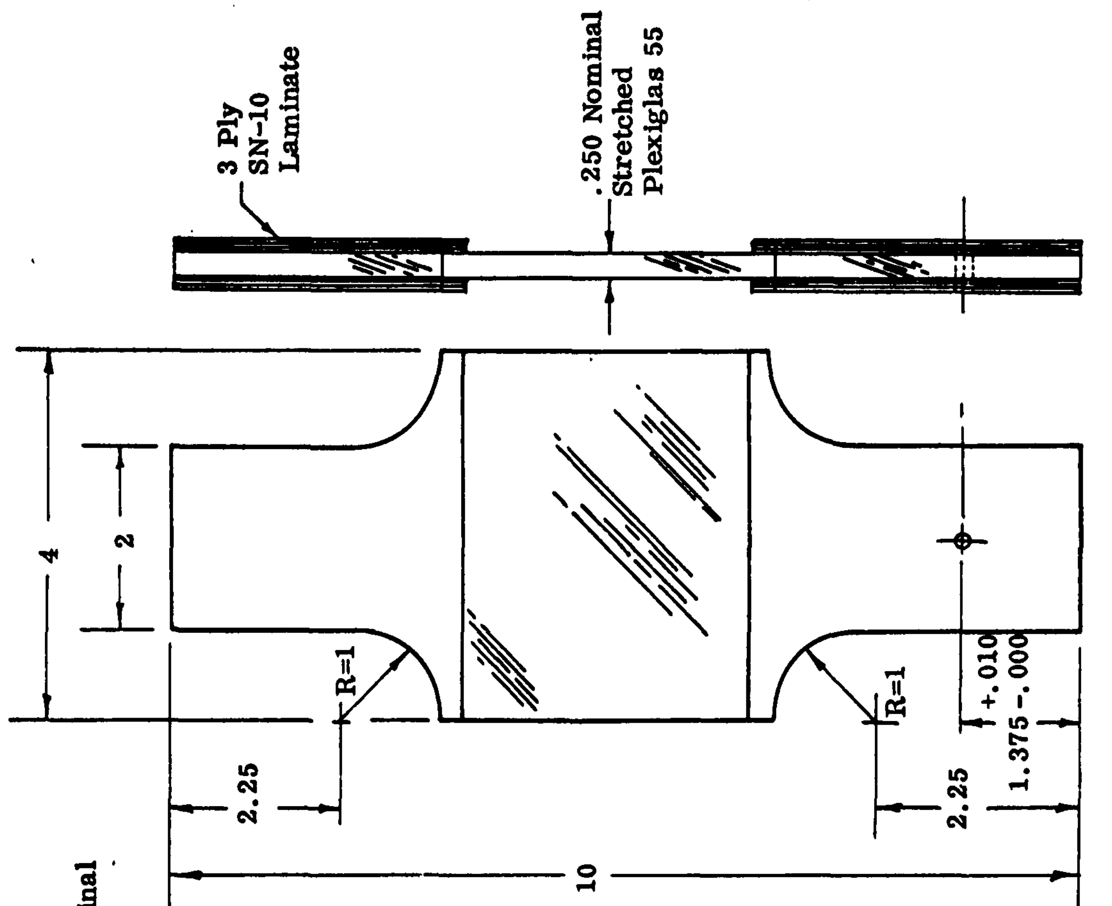
1) Stretched Plexiglas 55 - 0.25 sheet
2) SN-10 Nylon-Acrylic Laminate - 0.25 inches thick (11 plies)
3) Composite material - 0.25 Stretched Plexiglas bordered on front and back by 3 ply SN-10 Nylon-Acrylic Laminate (resin content 58.2%) bonded on with S47-AX cement.

BEARING TESTS

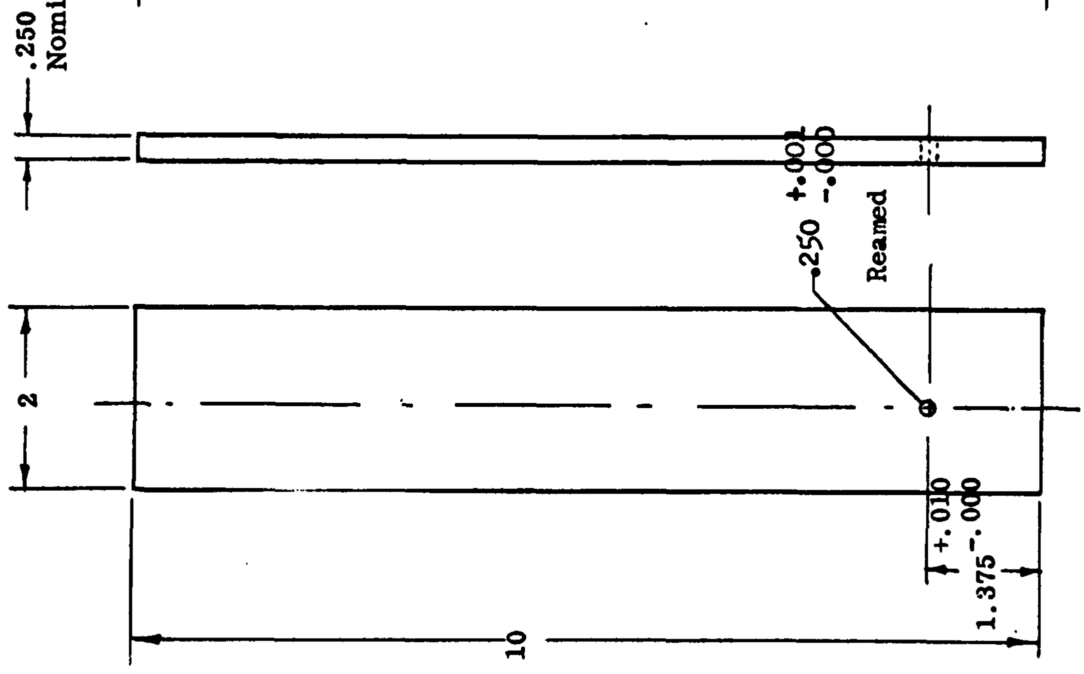
The test specimens employed for these tests are illustrated on page 2. These specimens were prepared twice scale of Fed. Spec. L-P-406 Method 1051. Method 1051 of Federal Spec. L-P-406 is limited to evaluating .125 stock. The bearing tests were conducted at -65°F, room temperature, and 200°F in accordance with the requirements of Fed. Spec. L-P-406 Method 1051. Bearing deformation was not recorded at -65°F.

FATIGUE TESTS

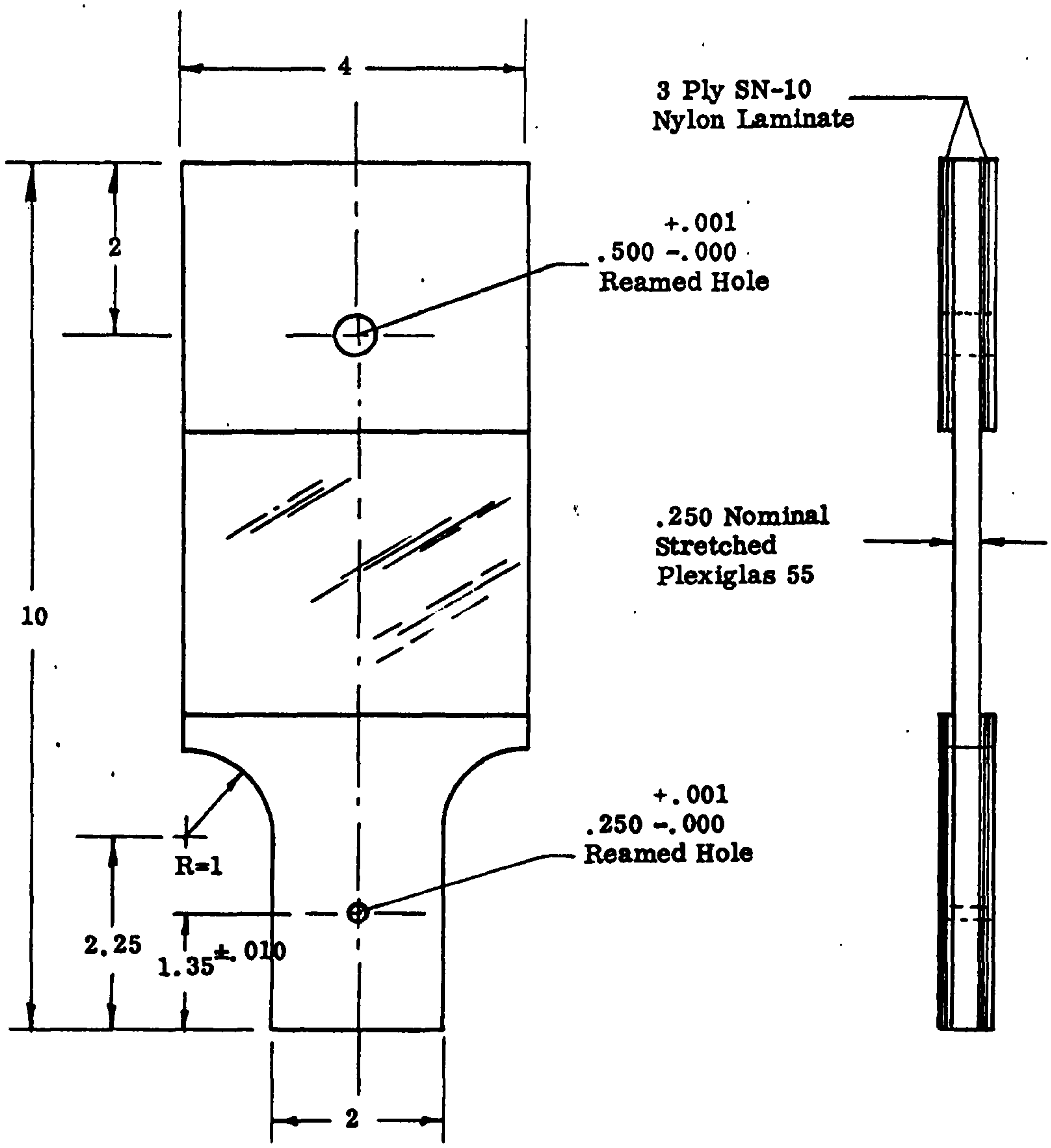
All fatigue bearing specimens were cut into the configuration illustrated by the composite material specimen on page 3. In addition to the hole edge distance of 1.375" (e/D = 5.5) shown, a number of specimens were fatigued with an edge distance of 5/8" (e/D = 2.5). The fatigue testing was conducted at room temperature with a cycling rate of 1800 cpm and a stress ratio R = .167.



Typical Static Bearing Specimen of Composite Material



Typical Static Bearing Specimen of Plexiglas or Laminate



Typical Fatigue Bearing Specimen
(Composite Configuration Study)

ROOM TEMPERATURE BEARING STRENGTH

Specimen No.	t (in.)	Bearing Area (in.^{2})	Stress At 4% E. (PSI)	Ultimate Stress (PSI)
		Stretched Plexiglas 55		
B1	.248	.062	20,300	32,250
B2	.248	.062	16,200	37,400
B3	.247	.062	20,100	36,000
B4	.246	.062	17,700	34,400
B5	.246	.062	15,300	38,000
		Average	17,920	35,610
		SN-10 Nylon-Acrylic Laminate		
1-2	.254	.064	12,600	37,250
1-3	.253	.063	12,700	36,800
23-1	.257	.064	9,380	36,600
1-5	.253	.063	11,500	37,000
22-1	.256	.064	10,700	35,250
		Average	11,375	36,580
		Plexiglas and Laminate Composite		
A1	.402	.10	7,500	27,450
A2	.399	.10	16,000	25,150
A3	.400	.10	10,000	24,550
A4	.400	.10	19,000	24,350
A5	.398	.10	14,750	24,100
		Average	13,462	25,120

BEARING STRENGTH AT +200°F

Specimen No.	t (in.)	Bearing Area (in.^{2})	Stress At 4% E. (PSI)	Ultimate Stress (PSI)
		Stretched Plexiglas 55		
B6	.245	.061	10,625	25,600
B7	.245	.061	7,000	25,700
B8	.245	.061	12,630	25,700
B9	.245	.061	12,280	27,000
B10	.245	.061	8,600	27,700
		Average	10,227	26,340
		SN-10 Nylon-Acrylic Laminate		
1-4	.253	.063	1,740	17,800
1-7	.254	.064	1,180	17,800
1-8	.254	.064	1,180	18,100
1-9	.255	.064	1,250	17,650
1-10	.255	.064	1,250	17,820
		Average	1,320	17,834
		Plexiglas and Laminate Composite		
C-1	.409	.102	7,100	21,750
C-2	.412	.103	7,900	23,200
C-3	.415	.104	8,450	20,250
C-4	.415	.104	5,720	21,500
C-5	.410	.102	9,560	23,100
		Average	7,746	21,960

BEARING STRENGTH AT -65°F

Specimen No.	t (in.)	Bearing Area (in.^{2})	Ultimate Stress (PSI)
		Stretched Plexiglas 55	
A-1	.238	.06	23,350
A-2	.239	.06	26,600
A-3	.242	.06	23,000
A-4	.245	.061	23,750
A-5	.245	.061	24,450
		Average	24,230
		SN-10 Nylon-Acrylic Laminate	
1-17	.257	.064	56,500
1-18	.256	.064	55,000
1-19	.257	.064	58,750
1-20	.257	.064	53,500
1-21	.257	.064	53,550
		Average	55,460
		Plexiglas and Laminate Composite	
B-1	.403	.10	30,500
B-2	.402	.10	31,530
B-3	.400	.10	31,200
B-4	.401	.10	31,400
B-5	.407	.10	30,700
		Average	31,066

ROOM TEMPERATURE ULTIMATE NET TENSILE STRESS AND NOMINAL LOAD CARRIED PER UNIT WIDTH

Specimen No.	Net Tensile Area (in^2)	Ultimate Load (lbs.)	Ultimate Net Tensile Stress (PSI)	Nominal Tensile Load - Ultimate (#/Linear in.)
		Stretched Plexiglas 55		
B1	.434	2,020	4,650	1,010
B2	.434	2,320	5,350	1,160
B3	.433	2,245	5,200	1,122
B4	.431	2,140	4,970	1,040
B5	.431	2,360	5,480	1,180
Average		2,217	5,130	1,108

SN-10 Nylon-Acrylic Laminate

No.	(in^2)	(lbs.)	(PSI)	#/Linear In.
1-2	.437	2,370	5,430	1,190
1-3	.435	2,325	5,350	1,170
1-23	.442	2,310	5,230	1,160
1-5	.436	2,335	5,350	1,175
1-22	.439	2,260	5,150	1,135
Average		2,320	5,300	1,165

Stretched Plexiglas 55 & SN-10 Nylon-Acrylic Composite

Specimen No.	Net Tensile Area of Composite (in^2)	% of Net Tensile Area Contributed by Plexiglas	Ultimate Load (lbs.)	Avg. Ult. Net Tensile Stress of Composite (PSI)	Nom. Tensile Load for Composite (#/Linear in.)
A1	.70	62.2	2,745	3,930	1,380
A2	.69	62.5	2,515	3,650	1,260
A3	.69	62.0	2,455	3,560	1,230
A4	.69	62.0	2,435	3,530	1,220
A5	.69	62.3	2,410	3,500	1,210
Average			2,512	3,635	1,260

+200°F ULTIMATE NET TENSILE STRESS AND NOMINAL LOAD CARRIED PER UNIT WIDTH

Stretched Plexiglas 55

Specimen No.	Net Tensile Area (in^2)	Ultimate Load (lbs.)	Ultimate Net Tensile Stress (PSI)	Nominal Tensile Load - Ultimate (#/Linear in.)
B6	.429	1,560	3,640	780
B7	.430	1,570	3,660	785
B8	.430	1,570	3,660	785
B9	.429	1,650	3,840	825
B10	.429	1,690	3,940	845
Average		1,608	3,750	805

SN-10 Nylon-Acrylic Laminate

Specimen No.	Net Tensile Area (in^2)	Ultimate Load (lbs.)	Ultimate Net Tensile Stress (PSI)	Nominal Tensile Load - Ultimate (#/Linear in.)
1-4	.435	1,125	2,560	565
1-7	.437	1,130	2,560	567
1-8	.437	1,150	2,580	578
1-9	.438	1,130	2,550	568
1-10	.438	1,145	2,560	575
Average		1,136	2,560	570

Stretched Plexiglas 55 & SN-10 Nylon-Acrylic Composite

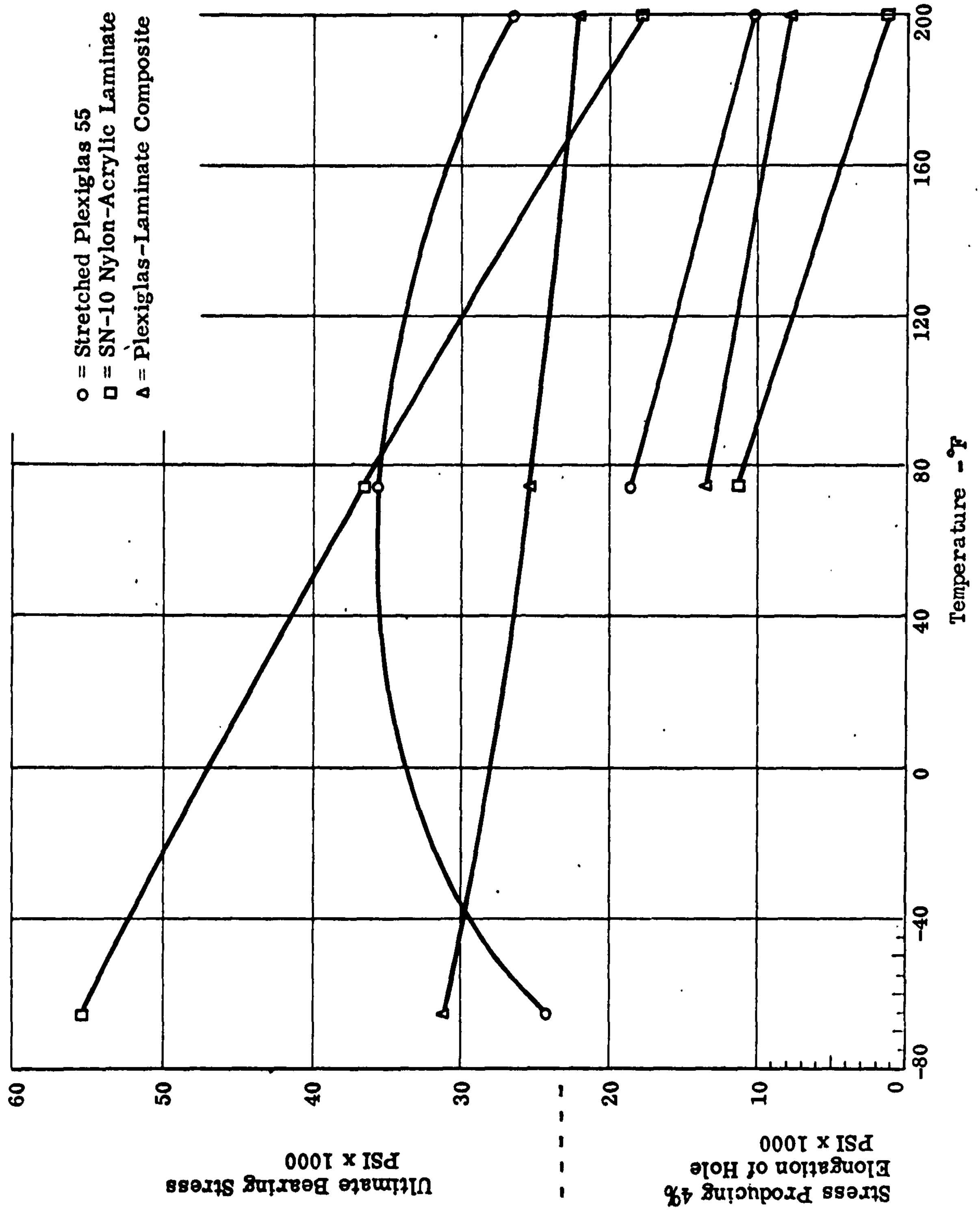
Specimen No.	Net Tensile Area of Composite (in^2)	% of Net Tensile Area Contributed by Plexiglas	Ultimate Load (lbs.)	Average Ult. Net Tensile Stress of Composite (PSI)	Nom. Tensile Load for Composite (#/Linear in.)
C1	.717	61.2	2,225	3,110	1,110
C2	.718	59.9	2,395	3,340	1,200
C3	.720	59.4	2,130	2,960	1,070
C4	.722	59.4	2,250	3,120	1,130
C5	.716	60.0	2,360	3,290	1,185
Average			2,272	3,165	1,140

-65°F ULTIMATE NET TENSILE STRESS AND NOMINAL LOAD CARRIED PER UNIT WIDTH

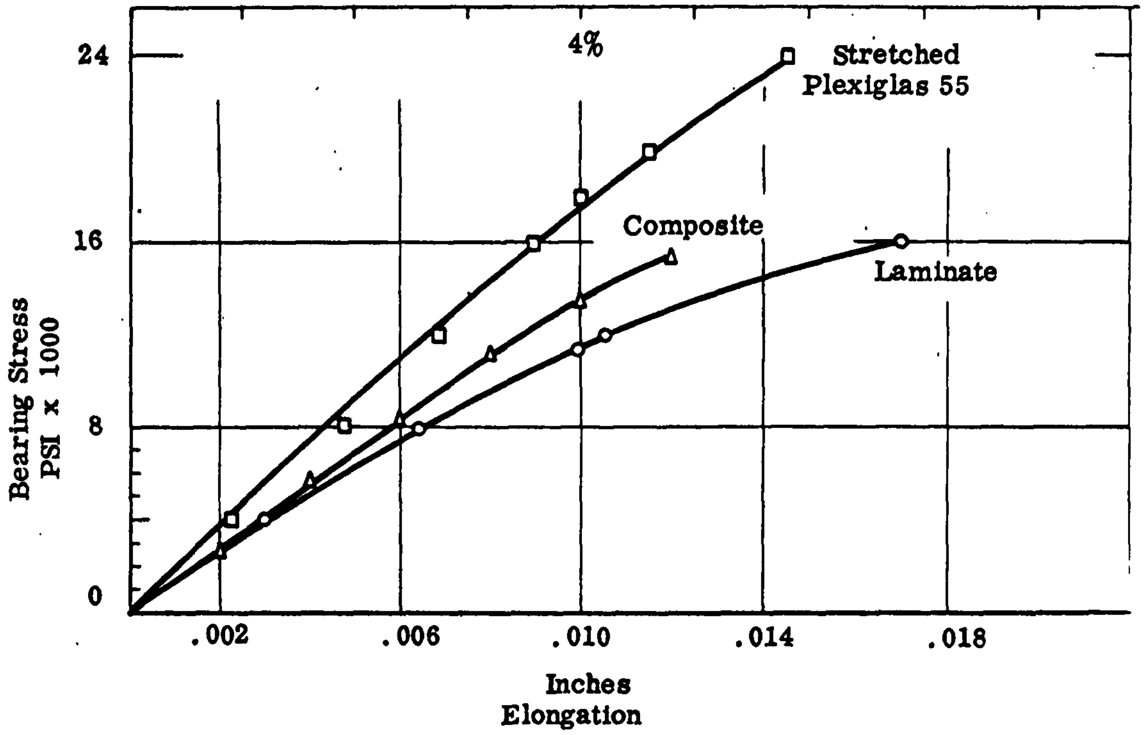
Specimen No.	Net Tensile Area (in^2)	Ultimate Load (lbs.)	Ultimate Net Tensile Stress (PSI)	Nominal Tensile Load - Ultimate (#/Linear in.)
		Stretched Plexiglas 55		
A1	.417	1,390	3,350	695
A2	.418	1,600	3,830	800
A3	.423	1,380	3,260	690
A4	.429	1,450	3,380	725
A5	.429	1,490	3,480	745
Average		1,462	3,460	730
		SN-10 Nylon-Acrylic Laminate		
1-17	.440	3,620	8,230	1,850
1-18	.440	3,511	8,000	1,760
1-19	.441	3,775	8,570	1,900
1-20	.440	3,415	7,770	1,720
1-21	.441	3,420	7,770	1,720
Average		3,548	8,060	1,790

Stretched Plexiglas 55 & SN-10 Nylon-Acrylic Composite

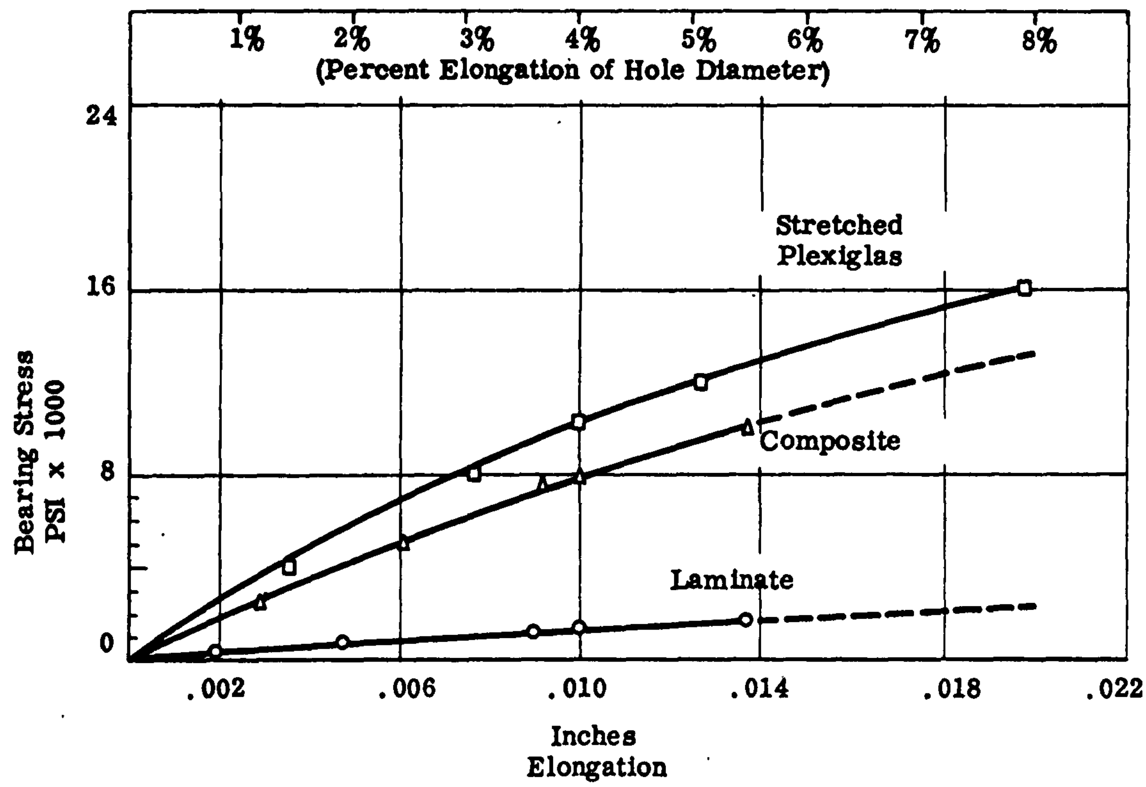
Specimen No.	Net Tensile Area of Composite (in^2)	% of Net Tensile Area Contributed by Plexiglas	Ultimate Load (lbs.)	Average Ult. Net Tensile Stress of Composite (PSI)	Nom. Tensile Load for Composite (#/Linear in.)
B1	.693	60	3,050	4,400	1,540
B2	.690	60	3,153	4,570	1,590
B3	.688	62	3,120	4,540	1,570
B4	.690	61.5	3,140	4,550	1,580
B5	.700	61.0	3,070	4,390	1,540
Average			3,106	4,490	1,565



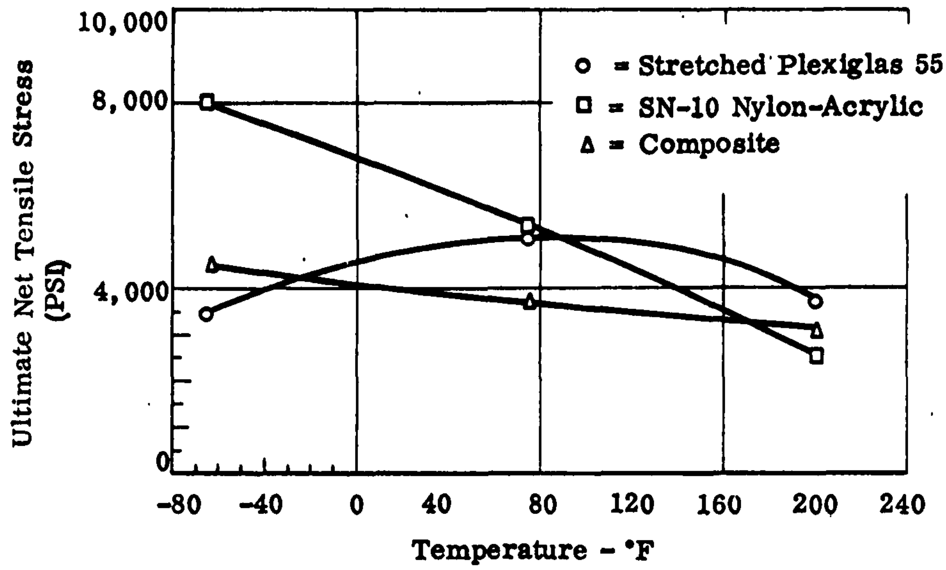
Bearing Stress and Hole Deformation vs Temperature



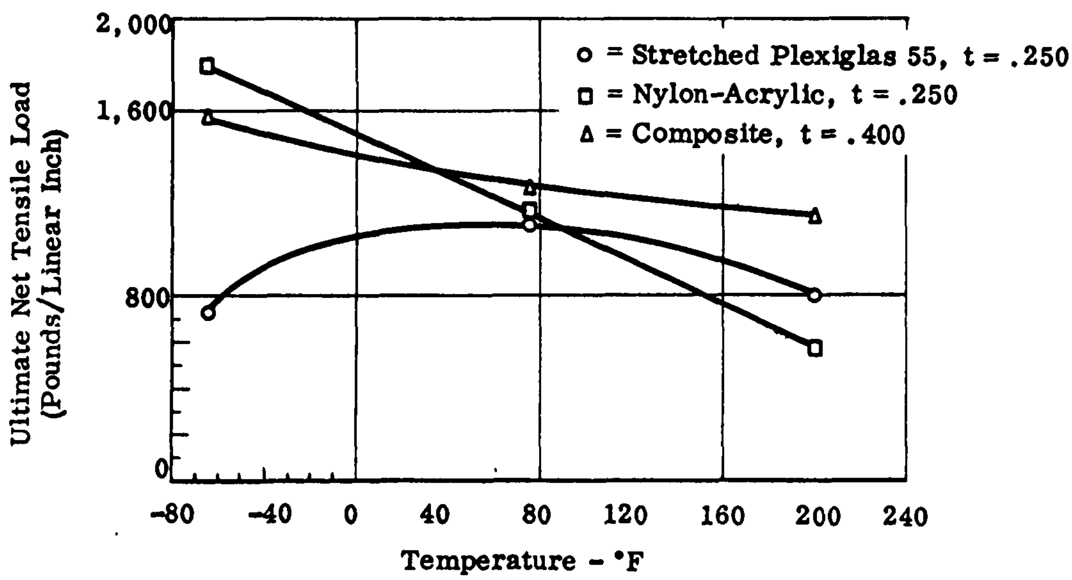
Room Temperature Bearing Stress vs Elongation of the Bearing Hole



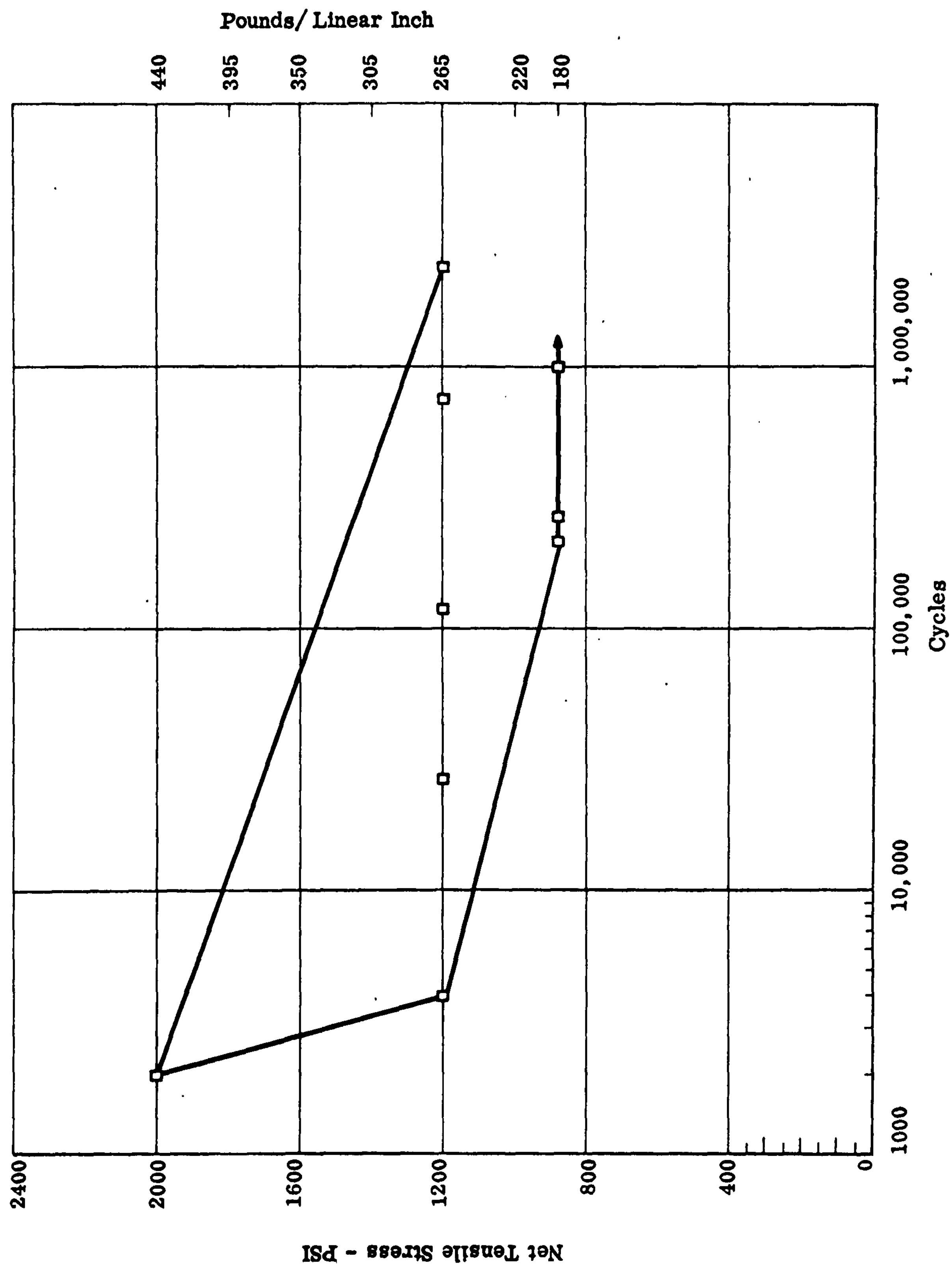
+200°F Bearing Stress vs Elongation of Hole



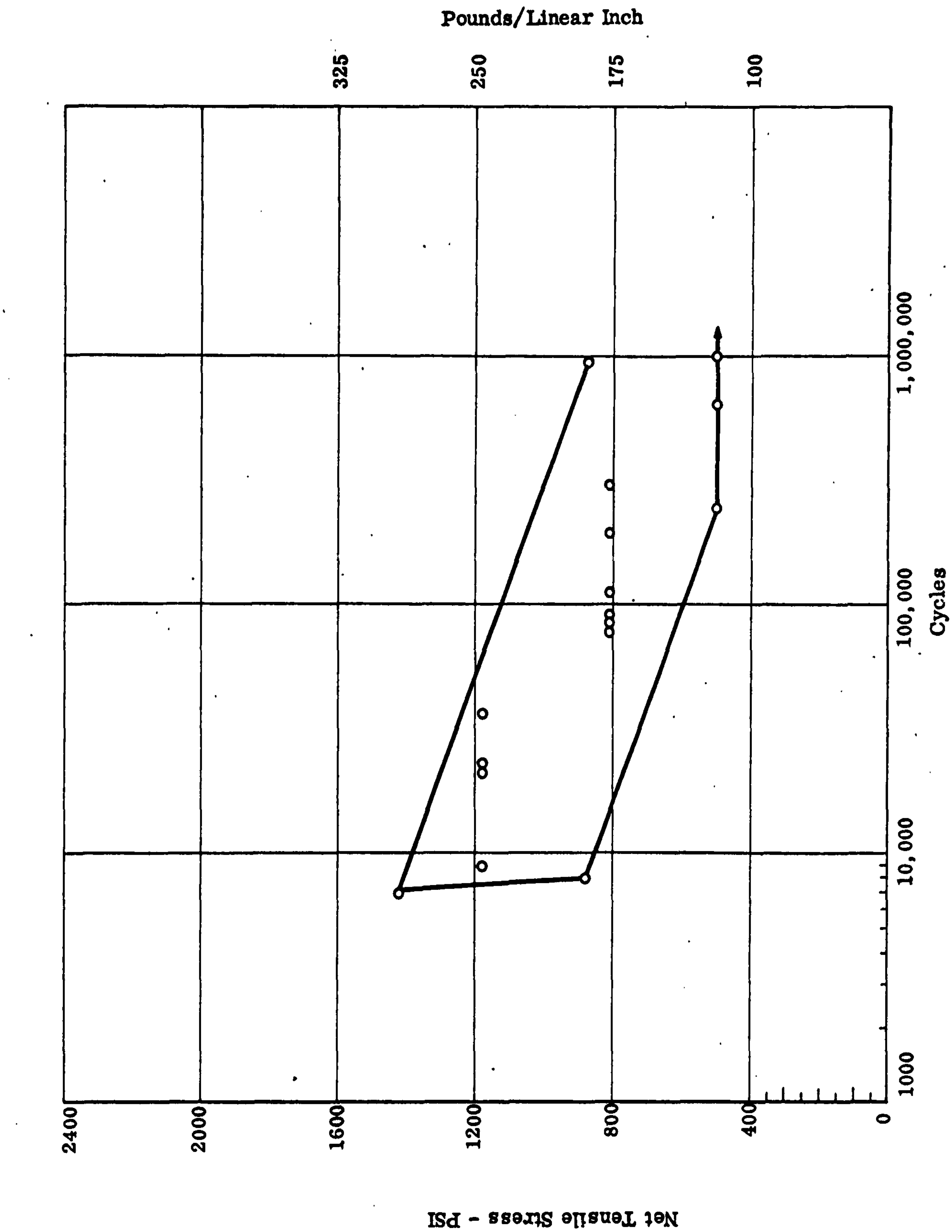
Notch Tensile Stress vs Temperature



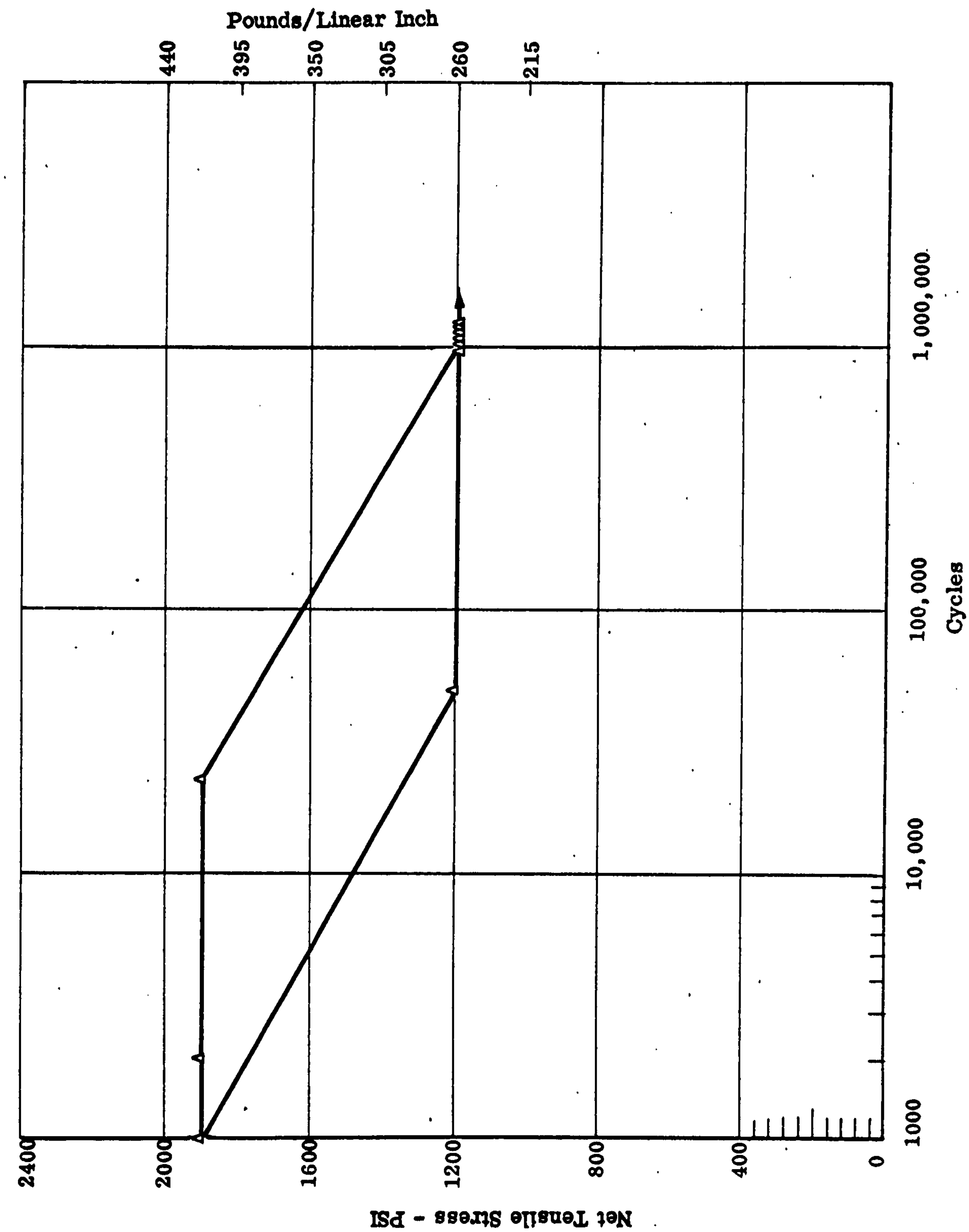
Tensile Load per Linear Inch
vs Temperature



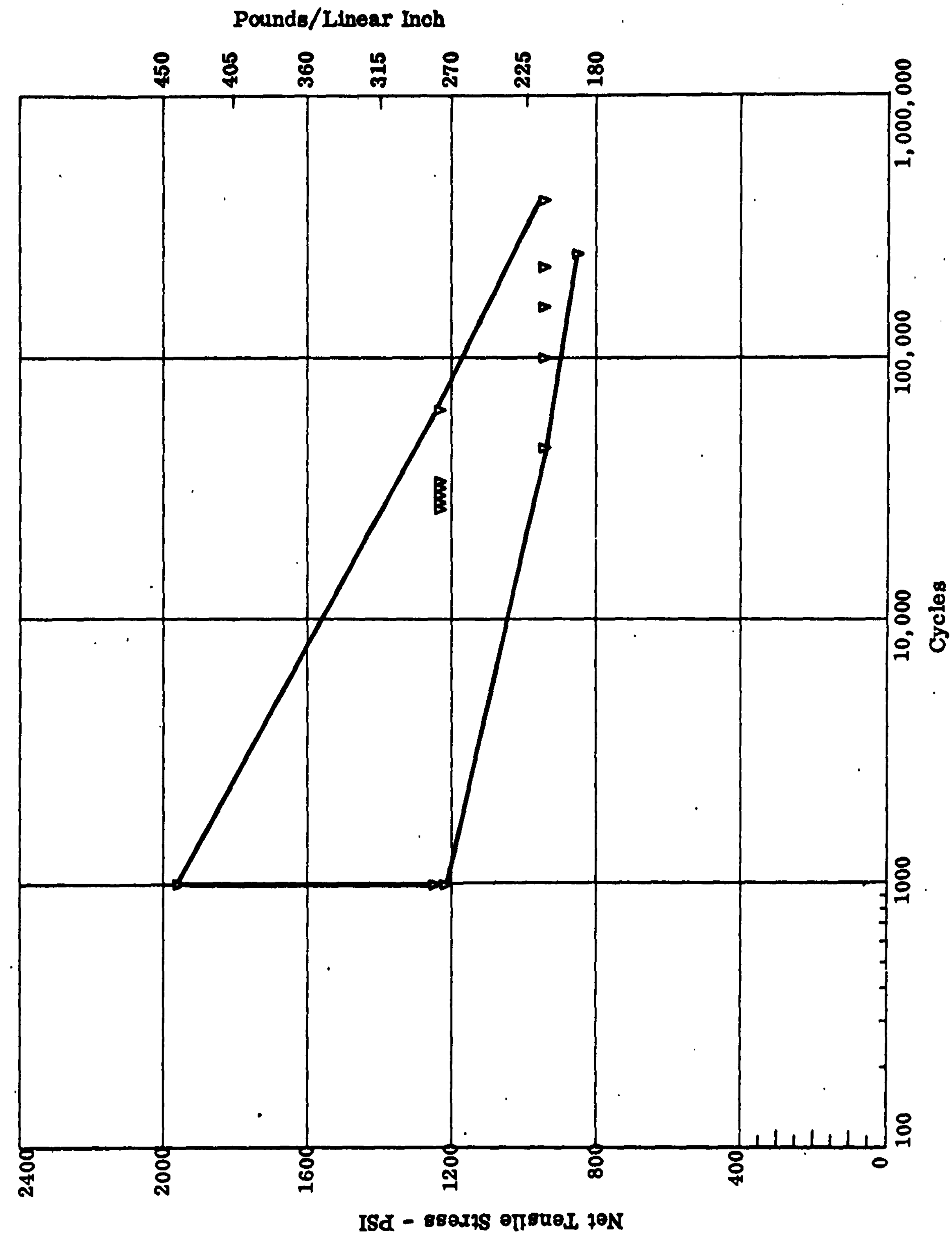
Envelope of Fatigue Results for Stretched Plexiglas 55 with 1-3/8 Inch Hole-edge Distance



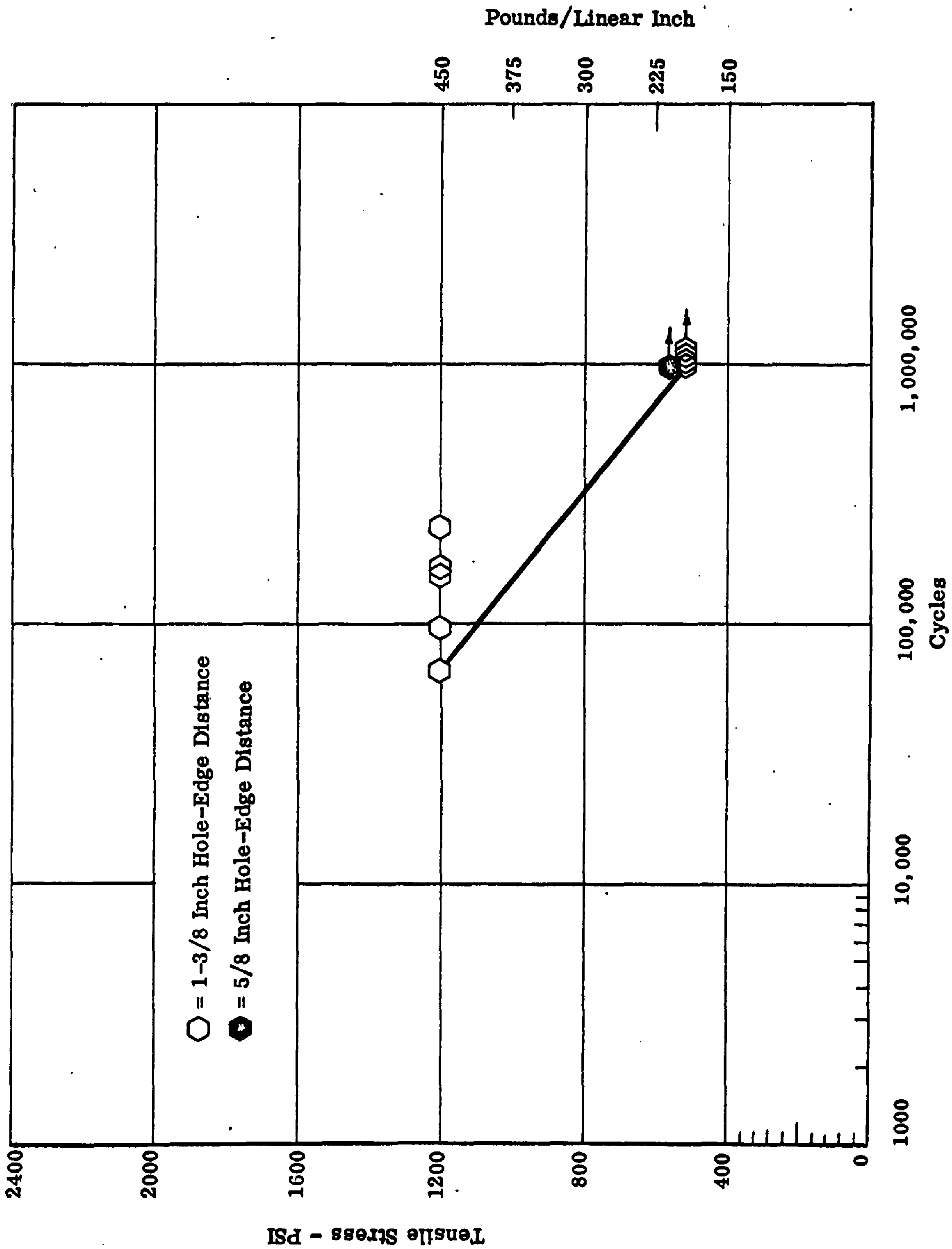
Envelope of Fatigue Results for Stretched Plexiglas 55 with 5/8 Inch Hole-edge Distance



Envelope of Fatigue Results for SN-10 Nylon-Acrylic Laminate with 1-3/8 Inch Hole-edge Distance



Envelope of Fatigue Results for SN-10 Nylon-Acrylic Laminate with 5/8 Inch Hole-edge Distance



Envelope of Fatigue Results for Composite Specimen

MECHANICAL PROPERTIES OF PLEXIGLAS II

MATERIAL IDENTIFICATION (COML.)	MATERIAL STATUS
As Cast Plexiglas II	Production
HEAT OR BATCH NUMBER	**FORM**
Unavailable	.250 Sheet

PROCESSING CONDITION

Not Applicable

OBJECT OF TEST	RAC DATA REF.
Determine bearing strength of "as cast" Plexiglas II	ERMR 4615 Dated October 15, 1958

SPECIMEN TYPE

Bearing specimens prepared twice scale of Fed. Spec. L-P-406 Method 1051 (27 September 1951).

TEST METHOD:

Bearing tests were conducted at Room Temperature and 200°F in accordance with Method 1051 of Fed. Spec. L-P-406.

Federal Specification L-P-406 Method 1051 is limited to evaluating .125 stock. Conformance to specification requirements was attained by increasing the dimensions of the test specimen in proportion to the increased thickness of the test material. An edge distance ratio of 5 times the hole diameter was maintained.

Bearing Strength at Room Temperature as Cast Plexiglas II

Specimen Number		Bearing Area	Load at 4% Elong.	Stress at 4% Elong.	Ultimate Load	Ultimate Stress	Type* Failure
	inches	inches^2	lbs.	PSI	lbs.	PSI	
1	.271	.0675			2630	39,000	A
2	.241	.0603	1225	20,250	2110	31,000	A
3	.265	.0662	815	12,250	1590	24,000	A
4	.254	.0533	1150	18,150	1495	23,500	A
5	.240	.0600	1175	19,500	1285	20,150	A
6	.245	.0612	1200	19,600	2240	36,500	A
7	.271	.068	1015	14,900	1175	17,250	A
8	.266	.0665			1390	20,900	A
9	.272	.068	1150	16,950	1760	25,850	A
10	.239	.0600	1012	16,800	2200	36,600	A
Average			1093	16,175	1787	27,475	

* "A" Type Failure characterized by tensile break across the bolt hole.

Bearing Strength at 200°F
As Cast Plexiglas II

Specimen Number		Bearing Area	Load at 4% Elong.	Stress at 4% Elong.	Ultimate Load	Ultimate Stress	Type * Failure
	inches	inches²	lbs.	PSI	lbs.	PSI	
1	.259	.0646	675	10,450	1210	18,700	B
2	.251	.0628	650	10,350	1230	19,600	B
3	.266	.0664			1260	19,000	B
4	.255	.0638	875	13,700	1455	22,750	B
5	.248	.062	775	12,500	1345	21,700	B
6	.270	.0675			1475	21,800	A
7	.270	.0675	682	10,100	1390	20,600	A
8	.267	.0668	682	10,250	1465	22,000	A
9	.273	.0682	650	9,530	1310	19,200	A
10	.261	.0652	662	10,150	1200	18,400	A
Average			706	10,879	1334	20,375	

* "A" Type Failure characterized by tensile break across the bolt hole.

"B" Type Failure - See Table I

THERMO-PHYSICAL PROPERTIES OF U-700

MATERIAL IDENTIFICATION (COML.) Udimet 700 (Kelsey Hayes Co.)	MATERIAL STATUS Experimental
HEAT OR BATCH NUMBER 5-2031	FORM .040" Thick Sheet
PROCESSING CONDITION As rolled	
OBJECT OF TEST To determine thermal expansion characteristics.	RAC DATA REF. RAC unpublished test data, dated 14 July 1960, Ref. MRP W.O. 58-128
SPECIMEN TYPE U-Channel, .040" Thick x 75" Wide x .50 Flanges x 10" Long	

TEST METHOD:

A ten-inch long Udimet 700 sheet metal specimen was heated from room temperature (70 °F) to 1500 °F. Length of specimen was measured and recorded at intervals of 100° F.

CHEMICAL COMPOSITION (BY WEIGHT)*

	Nominal	Heat 5-2031
Carbon	.15 Max	0.07
Aluminum	3.75 - 4.75	4.3
Titanium	3.00 - 4.00	3.39
Molybdenum	4.50 - 5.75	5.20
Chromium	13.00 - 17.00	15.4
Cobalt	17.00 - 20.00	18.6
Iron	1.0 Max	0.34
Boron	.10 Max	.029**
Silicon	--	less than 0.10
Manganese	--	less than 0.10
Copper	--	less than 0.10
Zirconium	--	less than 0.05
Nickel	Remainder	Remainder

* Ladle analyses as reported by vendor.

** After rolling .040 sheet boron content reduced to 0.17.

THERMAL EXPANSION OF UDIMET 700

Temperature °F	Specimen Length (in)	Coef. of Expansion From 70°F - in/in/°F
70	10.0030	-----
200	10,0095	4.99×10^{-6}
300	10,0175	6.30
400	10.0250	6.66
500	10.0300	6.28
600	10.0375	6.51
700	10.0445	6.59
800	10.0500	6.44
900	10.0570	6.50
1000	10.0640	6.56
1100	10.0710	6.60
1200	10.0775	6.59
1300	10.0860	6.75
1400	10.0910	6.61
1500	10.0950	6.43

MATERIAL IDENTIFICATION (COML.)	MATERIAL STATUS
Trufoam F-100 (Republic Aviation)	Semi-Production
HEAT OR BATCH NUMBER	**FORM**
See data below	Various shaped solid foams

PROCESSING CONDITION

Thermal testing was conducted on foamed samples after post-curing for a minimum of 4 days at 250°F

OBJECT OF TEST	RAC DATA REF.
To determine the thermal properties of epoxy foams when used as doppler lenses	MRP 59-6-3, March 6, 1961

SPECIMEN TYPE

Thermal shock - 18.0 dia. x 4.75 deep conical lens (page 5 of 5).
Coefficient of expansion - 1 x 1/2 rectangular section x length indicated.

TEST METHOD:

Thermal shock tests were conducted in conformance with the requirements of MIL-E-5272A. The conditions of test entailed a series of repetitive exposures to -40°F and 190°F. Dimensional measurements were obtained by using feeler gages against a face template, and diametric changes were obtained with a vernier caliper. Station locations were as shown on page 5. The lens was completely unrestrained during test.

Linear coefficient of thermal expansion was conducted on rectangular sections of fully post cured stock. The thermal gradient along the length of the specimen was controlled to be within 1°F. The thermal expansion measurements were obtained with a vernier caliper positioned on parallel blocks.

Table I - Thermal Shock Test of Trufoam F-100**

Column A was obtained before thermal shock
Column B was obtained after a four day post cure at 250°F
Column C was obtained after:

4 hours at 190°F)
4 hours at -40)
4 hours at 190) Thermal shock exposure
4 hours at -40)
4 hours at 190)
4 hours at -40)

Column D is the difference between A & B
Column E is the difference between B & C
Column F is the sum of D & E

Dimensional Measurements, inches

Sta. No.	A	B	C	D	E	F
1	.0015	.0045	.0195	+.003	+.015	+.018
2	.0025	.0035	.0075	+.001	+.004	+.005
3	.0055	.0075	.0095	+.002	+.002	+.004
4	.0025	.0065	.0045	+.004	-.002	+.002
5	.0025	.0065	.0025	+.004	-.002	+.002
6	*.002	.0055	*.002	+.004	-.004	.000
7	.0025	.0105	.0035	+.008	-.007	+.001
8	.0025	.0015	.0045	+.009	-.007	+.002
9	.0035	.0135	.0025	+.010	-.011	-.001
10	.0035	.0145	.0025	+.011	-.012	-.001
11	*.002	.0105	*.002	+.009	-.009	.000
12	.0025	.0065	*.002	+.004	-.005	-.001
13	.0035	.0055	*.002	+.002	-.004	-.002
14	.0025	*.002	.0025	-.001	+.001	.000
15	.0035	.0045	.0055	*.001	+.001	+.002

* less than

** RAC formulated epoxy foam (nominal 25 lbs/ft^3 density)

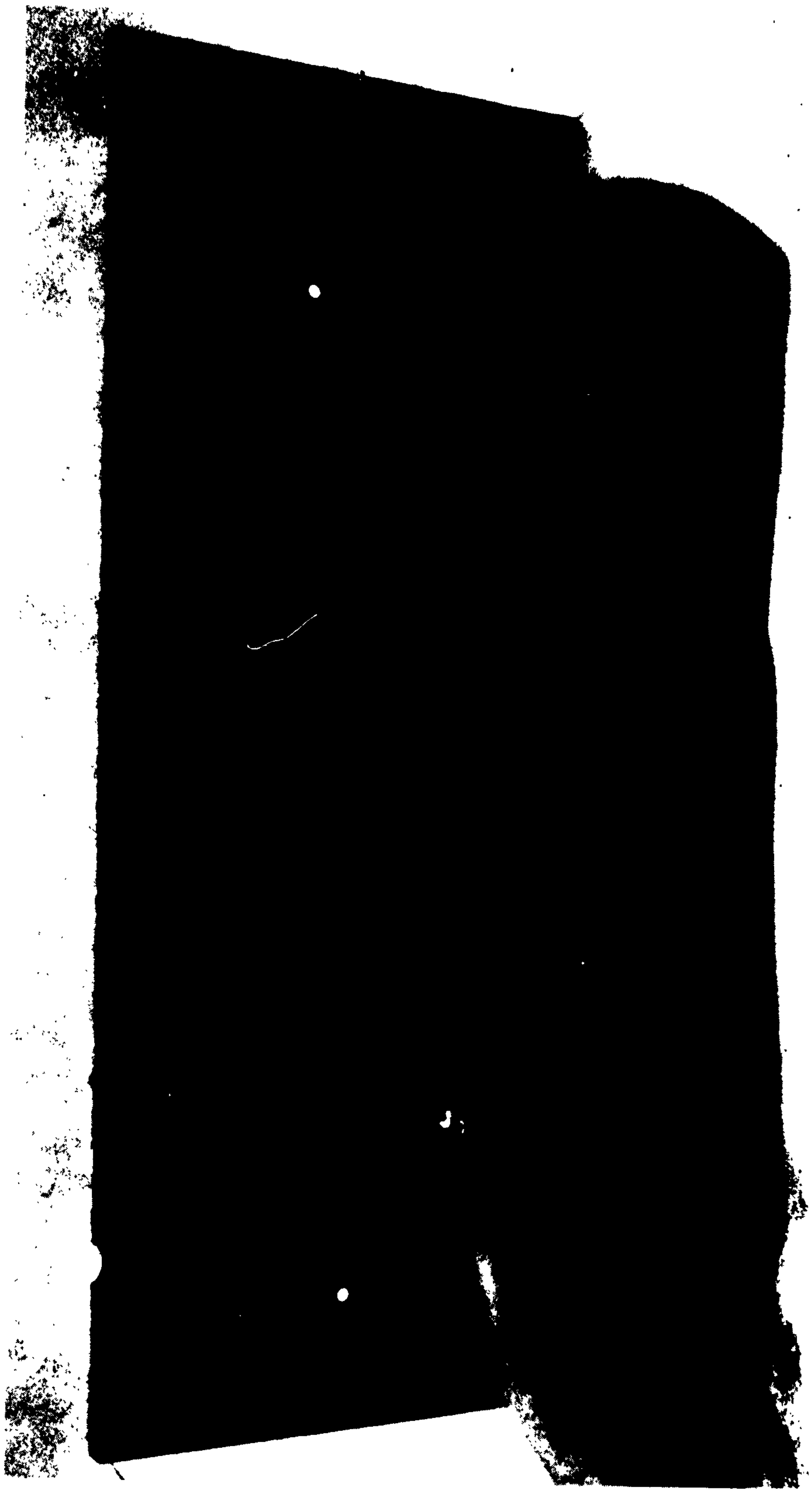
Sta. No.	A	B	C	D	E	F
16	.0055	.0055	.0095	+.000	+.004	+.004
17	.0035	*.002	.0085	-.001	+.006	+.005
18	.0055	.0085	.0195	+.003	+.011	+.008
19	.0045	*.002	*.002	-.003	.000	-.003
20	.000	.007	.0165	+.007	+.0085	+.0150
21	.000	.006	.0145	+.006	+.0085	+.0145
22	.000	.025	.025	+.025	.000	+.025
23	.003	.022	.0185	+.019	+.0035	+.0225
24	.002	*.002	*.002	*.002	.000	*.002
Diameters						
25	18.000	17.975	17.950	-.025	-.025	-.050
26	18.000	17.988	17.965	-.012	-.023	-.035
27	17.990	18.000	17.970	+.010	-.030	-.020
28	11.505	11.513	11.520	+.008	+.007	+.015
Ambient Temperatures						
	76°F	71°F	71°F			

* less than

** RAC Formulated epoxy foam (nominal 25 lbs/ft^3 density)

Table II - Determination of Linear Coefficient of Expansion of Trufoam F-100

	Length at 77°F, Inches	Length at 160°F, Inches	Difference 77° - 160°F, Inches	Coefficient of Linear Expansion, in/in/°F
a.	3.152	3.160	.008	30.5×10^{-6}
b.	4.140	4.158	.018	52.5×10^{-6}
c.	4.107	4.116	.009	26.4×10^{-6}
			average	36.5×10^{-6}



ELECTRICAL PROPERTIES OF CONDUCTIVE AND REFLECTIVE RESINS

MATERIAL IDENTIFICATION (COML.) See data below	**MATERIAL STATUS** Experimental
HEAT OR BATCH NUMBER See data below	**FORM** Liquids and pastes

PROCESSING CONDITION
The coating under test was applied by brushing or spraying and allowed to air dry for a minimum of 24 hours

OBJECT OF TEST To determine the suitability of plastics for electrical applications	**RAC DATA REF.** MRD Report No. 59-38-1, June 24, 1960

SPECIMEN TYPE
Flat panels 11" x 11" x 0.1" thick epoxy fiberglass were coated with 0.005 - 0.010" thick coatings

TEST METHOD:

Electrical conductivity was measured with a vacuum tube volt meter. The volt meter probes were placed 10 inches apart on the surface of the panels.

Radar reflectivity measurements were recorded from positions on the panel. The positions were located at the midpoint of the four 5.5 inch square quadrants of the panel. The output of an X-band generator was positioned at a 20° incident angle and a high gain pick-up horn was adjusted for a 20° reflection angle. A VSW ratio meter was set at 100%, based on a standard polished aluminum sheet.

TABLE I

Reflectivity and Conductivity of Plastics

Material	Reflectivity - % Position I	Position II	Position III	Position IV	Conductivity DC-OHMS
Trulite S-1000*	97	99	100	96	$<$ 1 ohm
Trulite S-1000-1	91	95	93	96	20 ohms
Hysol 6250**	100	100	99	99	$<$ 1 ohm
Hysol 6250-6	71	62	50	64	infinite
Trulite S-2000	91	67	75	70	infinite
Trulite S-2000	90	100	95	100	infinite
Trulite S-1000-2	74	75	78	77	80,000 ohms
Trulite S-1000-3	51	52	55	52	infinite
Trulite S-1000-4	56	54	52	54	infinite
Trulite S-1000-5	57	64	56	60	infinite
Hysol 6251	52	54	48	48	infinite
Trulite S-2000-1	43	43	44	43	infinite
Flame Sprayed SF Aluminum	98	99	99	99	$<$1 ohm

* Trulite - RAC material

** Hysol - Hysol Corporation, Olean, N. Y.

MISCELLANEOUS PROPERTIES OF EPOXY TOOLING RESINS

MATERIAL IDENTIFICATION (COML.)

See data below

MATERIAL STATUS

Production

HEAT OR BATCH NUMBER

Not applicable

FORM

Liquids and pastes

PROCESSING CONDITION

Epoxy castings were catalyzed and poured at room temperature and allowed to cure for a minimum of 24 hours at room temperature.

OBJECT OF TEST

To evaluate epoxy resins for use as a general purpose tooling material

RAC DATA REF.

MRD 59-48-1, October 20, 1959

SPECIMEN TYPE

Flexural, compressive, impact, and density specimens were as per Federal Specification L-P-406b, Methods 1031, 1021.1, 1071 and 5012.

TEST METHOD:

The mechanical properties evaluated (Table I) were conducted in accordance with the testing procedures of Federal Specification L-P-406b. The physical properties of gel time and exotherm temperature were evaluated by casting 300 gms of catalyzed resin into a 4 inch diameter x 3 inch high wide mouth paper cup and positioning a thermocouple lead (connected to a Speedomax recorder) in the center of mass. The gel time was selected to be coincidental with the time of maximum exotherm as shown on the Speedomax recorder. The heat resistance service test conducted (Table II) was visual observation of the resin under test to act as a fastener for drill bushings. Thermocouples were attached to the bushing and then cast in place with the resin under test. The assembly was heated in increments of 50°F (starting at 100°F to 500°F) held at temperature for a minimum of 15 minutes and visibly examined.

TABLE I

MECHANICAL AND PHYSICAL PROPERTIES OF EPOXY TOOLING RESINS

Test	Machine	Specimen Size	Trulite C-171*	Devcon B**	Devcon F	Devcon WR
Flexural Yield	Dillon Universal	1/2"x1/2"x10"	5600 psi	---	---	---
Compressive Yield	Dillon Universal	1/2"x1/2"x1	16600 psi	9500 psi	9400 psi	1200 psi
Izod Impact	Nat'l Forge Impact Tester	1/2"x1/2"x2-1/2"	0.5 ft-lb/in	---	---	---
Gel Time at 75°F	Speedomax Recorder	300 grams	42 min.	48 min.	---	---
Max. Exotherm Temp.	Speedomax Recorder	300 grams	250°F	260°F	---	---
Approx. Density (cured)	---	---	103 lb/ cu. ft.	158 lb/ cu.ft.	---	112 lb/ cu. ft.

* RAC formulated epoxy tooling resin

** Chemical Development Corporation epoxy tooling resin

Note: Mechanical property data are representative of single specimens for each material

TABLE II

HEAT RESISTANCE OF EPOXY TOOLING RESINS

Epoxy Tooling Material	Exposure Temperature	COMMERCIAL BUSHINGS: Redskin	Ceram-A-Grip	Plain Press Fit
Trulite C-171	100°F	No visible effect	No visible effect	No visible effect
	150	"	"	"
	200	"	"	Slightly loose
	250	"	"	"
	300	"	Slightly loose	Quite loose
	350	"	Quite loose	----
	400	"	---	----
	450	"	---	----
	500	"(Max. heat achieved)	---	----
Devcon B	100°	No visible effect	No visible effect	No visible effect
	150	"	"	"
	200	"	Questionable effect	Slightly loose
	250	"	Slightly loose	Very loose - Devcon B like putty
	300	"	"	
	350	"	Slightly looser	----
	400	"	Not visibly looser	----
	450	Redskin begins to melt	when temp. maintained	----
	500	Bushing loose in redskin	for 10 minutes	----
Devcon WR	100°F	No visible effect	No visible effect	----
	150	"	"	----
	200	"	"	----
	250	"	Slightly loose	----
	300	"	"	----
	350	"	Quite loose	----
	400	"	Very loose	----
	450	"	----	----
	500	Redskin begins to melt with very little smoke and no great color change	----	----